Technical Research Report 1163

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SEARCH EFFECTIVENESS WITH PASSIVE NIGHT VISION DEVICES

Jack J. Sternberg and James H. Banks

COMBAT SYSTEMS RESEARCH DIVISION

BESRL

Behavior and Systems Research Laboratory
Office of the Chief of Research and Development
U. S. Army

June 1970

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104

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J. E. UHLANER
Director

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Jack J. Sternberg and James H. Banks

COMBAT SYSTEMS RESEARCH DIVISION
Aaron Hyman, Chief

BEHAVIOR AND SYSTEMS RESEARCH LABORATORY

Office, Chief of Research and Development
Department of the Army

Room 239, The Commonwealth Building
1320 Wilson Boulevard, Arlington, Virginia 22209

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FOREWORD

The Night Operations Program within the Behavior and Systems Research Laboratory is concerned with problems in optimizing human performance in relation to night vision devices and related sensors. Specific aspects deal with determining: performance effectiveness of sensor systems; factors which affect performance; and means of improving effectiveness. The entire research program is responsive to requirements of the Combat Developments Command and is conducted under RDT&E Project 2Q024701A723, Human Performance in Military Systems, FY 1971 Work Program.

To further the research, a field unit has been established at Fort Ord, California, where, with the support of the Combat Developments Command Experimentation Command (CDCEC), studies are currently being conducted with passive night vision devices. Personnel of the Behavior and Systems Research Laboratory are deeply appreciative of the excellent support given the research program by CDCEC, both in personnel and materiel. Special acknowledgment is made of the efforts of the Commander, Brigadier General T. W. Brown and of Project Team III which, under the command of Lieutenant Colonel G. Van Hazel, directly supported the research activity.

The present publication describes the research methodology and findings from the first of a series of research phases of the BESRL program. These findings provide information on performance with the night vision devices and test technologies for field experimentation as rapidly as the information becomes available and do not represent a complete analysis of the results. The research is aimed at providing information to operational users, training commands, and as an aid to other researchers in the area. Follow-up reports, analyzing other portions of the data, are in preparation.

J. E. UHLANER, Director
Behavior and Systems
Research Laboratory

SEARCH EFFECTIVENESS WITH PASSIVE NIGHT VISION DEVICES

BRIEF

Requirement:

To assess performance effectiveness with selected passive night vision devices. The first operational objective was to determine which factors affect performance, and to what extent. The second objective was to identify and develop means of improving performance effectiveness.

Procedure:

Four devices, the Miniscope (MINI), Starlight Scope (SS), Crew Served Weapon Night Vision Sight (CSWS), and the Night Observation Device, Medium Range (NOD), were evaluated simultaneously. One hundred twenty-three operators (players) were tested at the rate of nine per night. Testing was conducted under starlight, half-moon, and full-moon illumination conditions. The 72 targets presented each night were of different types, contrast, and modes, and stationed at distances of 100 to 1200 meters from the players. Operators searched a hetergeneous terrain nearly continuously for a period of six hours. Detection responses and search behavior were recorded on magnetic tape. The data were analyzed to determine how effective performance was, and the effects of critical variables and search behavior on performance effectiveness.

Findings:

Operators differed greatly in their ability to detect targets during search. Operators showed low reliability in detection of specific targets. About 50 percent of the targets that could actually be seen were not found during search. The primary cause of inefficient performance was faulty search techniques.

Operators are capable of almost continuous use of the devices for relatively long periods (at least six hours) without degradation of performance, in contrast to previous reports of degradation after about 30 minutes.

Performance with the NOD was superior to performance with the other devices. Overall level of performance with the MINI, SS, and CSWS was much the same.

Pairs of operators using devices of the same type detected about 50 percent more targets than did single operators. All mixes (pairs) of the MINI, SS, and CSWS were about equally effective. Any mix which included the NOD improved performance.

Performance was greatly affected by a number of environmental-target-terrain factors, including ambient light, distance, target type, and target-background contrast.

Products:

Effective training procedures and a technique by which operators were able to make proper diopter adjustment of their devices were developed. The latter development in effect eliminated the strain which frequently led to headache, nausea, etc., with consequent degradation of performance.

Practicable and effective field experimentation methodology and instrumentation were developed which are applicable to a wide range of field experimentation and testing with night vision devices and sensors.

Utilization:

The study provided baseline performance data on passive night vision devices and information on the effect of critical factors on performance. The findings suggest how performance may be improved by operational employment, work methods and procedures, and new approaches to training and search techniques.

SEARCH EFFECTIVENESS WITH PASSIVE NIGHT VISION DEVICES

CONTENTS

TABLES

FIGURES | Page

SEARCH EFFECTIVENESS WITH PASSIVE NIGHT VISION DEVICES

BACKGROUND

The U. S. Army has in recent years recognized a need to improve its night operations capabilities. (See, for example, the 1964 study by the U. S. Army Combat Developments Command).[1] This need has led to the development of sensors which greatly improve night seeing and target acquisition capabilities. The development of these sensors has in turn created an urgent need for human factors research to determine and improve the level of human performance with the current generation of sensors and to provide human performance data which can be applied to improvement of the capabilities of future generations of sensors.

The Behavior and Systems Research Laboratory (BESRL) has established a Work Unit with the mission of conducting human performance experimentation to improve the capabilities of the combat soldier in night operations. Early work by this unit was conducted at Fort Benning, Georgia, in the winter of 1967-1968.[2] In the early summer of 1968, the U. S. Army Combat Developments Command (USACDC) requested that BESRL research in this area be expanded and accelerated. This request was formalized by USACDC in July 1968. Concurrently, USACDC requested that the U. S. Army Combat Developments Command Experimentation Command (USACDCEC), Fort Ord, California, support the desired BESRL research. Research by BESRL was initiated at Fort Ord in October 1968, with completion tentatively scheduled for September 1969.

In the course of the following year, it became obvious that a longer term research effort was required and that this could be best and most economically accomplished by the establishment of a field experimentation unit at Fort Ord. Initial exploration of the feasibility of such a unit was undertaken in mid-1969 and culminated in December 1969 in an intraservice support agreement establishing the BESRL Field Experimentation Unit as a tenant of Fort Ord with primary mission support continuing to be supplied by USACDCEC.

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[1] Night operations and the employment of night vision devices (Unclassified title). U. S. Army Combat Developments Command, November 1964. SECRET.

[2] Search effectiveness with the Starlight Scope and 7 x 50 binoculars. Behavior and Systems Research Laboratory. (In preparation).

OBJECTIVES

Performance Effectiveness

The Army has given high priority to the development and fielding of advanced systems for surveillance, target acquisition, and night observation. The effectiveness of any system is complexly determined by the characteristics of the system, the way in which the system is employed, and the behavior of the human being in the system. The system must be evaluated in terms of the interaction of all these factors rather than separately in terms of the effectiveness of the equipment, the method of employment, or the human operator. Systems measurement beds must be developed which permit the determination of the relative contribution of equipment factors, employment factors, human factors, and the interactions of all these, to total system effectiveness. When these contributions are understood, suggestions leading to improvement of total system effectiveness become possible.

To translate these considerations into specific questions, the research conducted by BESRL is designed to provide information which will aid in the solution of the following problems:

Who should use night vision devices and sensors? Individuals differ greatly in the abilities to acquire targets with these devices. To what are these differences attributable? To what extent can these differences be reduced by training? What kind of training is effective? If selection of operators is necessary, on what basis should selection be made?

How should the devices be used? What are the proper search techniques? What are the implications of human capabilities and limitations for employment and deployment of men and devices--how large an area can a man effectively search? How long can a man use a device effectively? What are suitable work-rest cycles? If two men are to use the devices, should the men be assigned separate or overlapping search sectors?

Which devices should be used and under what conditions? The devices differ in their characteristics and capabilities and are affected differently by changes in conditions. What is the relative performance with the devices under different light levels? On different types of targets? On targets at different distances? On different types of terrain--open versus cluttered with trees, brush, rocks? For different tactical applications?

What should be the Basis of Issue (BOI) and Mix of devices? How much is gained in target acquisition if two men with devices of the same type are used? If three men are used? How much is gained by the use of two or more men with different types of devices?

Questions such as these can be answered only by extensive and rigorous experimentation. The results of this experimentation provide information for operational employment, training, and selection, and for the development of concepts, doctrine, and organization. Also, the information provided forms a basis for subsequent troop tests. From such experimentation, too, the parametric data essential for effective linear modeling and war games are obtained. In addition, determination of the complex interactions of the man, the device, and the operational situation provides valuable information for the design of future generations of devices.

The present publication is an initial report, using descriptive statistics, of some of the research conducted at Fort Ord. The results are discussed in terms both of specific findings and of implications of the findings for improvement of effectiveness. A report containing more detailed analyses is in preparation, as are reports of additional experimentation.

Field Research Technology

In order to provide information on the effectiveness of the devices, a technology was required which would make it possible to collect reliable and valid experimental data under field conditions. Existing instrumentation, procedures, and techniques were not adequate for research of this type. Therefore, the second objective was the development of an appropriate technology--instrumentation, training, testing, control methods and procedures, special experimental techniques.

Instrumentation was necessary which would provide for accurate measures of target detection and search behavior. The instrumentation had to be flexible and reliable under widely varying field conditions, provide for simultaneous recording of a variety of data, allow for control and monitoring of the players, and provide a data output that could be rapidly analyzed. Methods and procedures had to be developed which would insure that all player, supporting, and controller personnel were properly carrying out their assigned missions. Each participant had to be oriented, motivated, and trained for his job. Because of the large number of test and environmental factors and the large number of differing types of personnel involved, a great deal of procedural redundancy, as well as constant monitoring, was required in order to maintain a standardized testing situation. Special experimental techniques had to be developed in order to identify and consider the effects of various factors on performance. Identification of the relative contribution of these factors to performance reveals which sub-system elements need to be improved in order to improve overall system effectiveness.

The technology is described in considerable detail in the Technical Supplement in order to make it available to others involved in field testing and experimentation. Admittedly, not all elements can be immediately transferred to other experiments, but portions can be readily used and the remainder, including the general principles involved, adapted to the specific requirements of other testing situations.

PROCEDURE

The devices tested were the Miniaturized Night Vision Sight, AN/PVS-3 (MINI), the Small Starlight Scope, AN/PVS-2 (SS), the Crew Served Weapon Night Vision Sight, AN/TVS-2 (CSWS), and the Night Observation Device, Medium Range, AN/TVS-4 (NOD). The effectiveness of these devices is determined by the interaction of device characteristics, test conditions, environmental factors, and the behavior of the soldier using the devices. Thus, interpretation of any evaluation of effectiveness is influenced by the particular conditions under which the evaluation was obtained.

Performance with all the devices was measured in a standard testing situation, or test bed; that is, the same target-terrain situation was used for all devices. The terrain used was flat to mountainous, bisected by a road, traversed by ravines and streams, with some large open grassy areas and some areas heavily cluttered with trees, brush, and rocks. The area to be searched was 75° wide and extended to 1500 meters. Targets were placed in this area at distances of 100 to 1200 meters from the players. Human and vehicular targets were presented both standing still and moving. Target-background contrast was manipulated by placing targets against appropriate backgrounds. Testing was conducted under starlight, half-moon and full-moon illumination conditions.

Prior to testing, approximately 90 minutes of training were given. The purpose of this training was to instruct the player in the use of his device (15 minutes), to teach him what targets looked like when seen through a night vision device (30 minutes), and to allow him to develop facility in the rapid detection and simulated shooting of the targets (45 minutes). Training was given on an individual basis. No instructions on how to search were given, but each player was told to use whatever technique he felt was most effective for him. During testing the ability of the players to find targets through search was determined. Testing was so conducted that performance could be measured under varying conditions of ambient light, distance, target mode (dynamic or static), target-type, and target-background contrast. These factors were selected from the large number of possible factors because previous research and pilot studies had indicated that they were especially critical determiners of performance. The parameters of these factors established for the experiment were such as to permit determination of device differences. Two measures of effectiveness were used: percentage of targets detected and the time required to detect these targets.

FINDINGS AND THEIR IMPLICATIONS

Overall, the level of performance with the MINI, SS, and CSWS, as measured by percent detections, was very similar, no device being markedly superior to the others. Performance with the NOD, however, was considerably better than with the other devices. The level of performance as measured by time to detect targets was similar for all four devices.

Critical Factors Affecting Performance

Performance with the four devices studied was affected, sometimes differentially, by a number of factors. All factors entering into the experiment except target mode affected performance in the expected manner--in accordance with previous research findings and logical expectations.

Ambient Illumination. Performance in terms of percent target detections improved considerably as the ambient light increased from starlight to full moon. Performance improvement was greatest (about 100%) for the MINI, SS, and CSWS, with relatively little difference among these devices. As increasing illumination did not improve the performance of one device more than it improved another, this finding indicates that it would not be advantageous, for example, to use one type of device under starlight conditions and another type under full-moon conditions. Performance with the NOD also improved, but only about 50%. This relatively smaller increase can be attributed to the NOD's relatively superior performance at low light levels.

Performance, as measured by the time required to detect targets, showed little or no difference among the devices. While slightly less time was required as the light level increased, the improvement was about the same for all devices. Two considerations enter into the interpretation of this result: 1) A relatively long time was required to find the targets; and 2) search time reported reflects the complexity of the task--search area size, terrain difficulty, target difficulty, etc. To the extent that the experimental target-terrain situation used in the study is found in a real-world combat situation, the result suggests limiting the size of the search area or increasing the Basis of Issue or mix.

Distance. The detection of targets was found to be highly related to distance from the target for all devices and at all light levels. Relatively few targets were detected at far distances. The MINI, SS, and CSWS showed serious limitations beyond 800 meters. As the NOD is intended to be used at longer distances, performance with the NOD showed relatively less decrement at these distances.

Target Mode--Dynamic vs Static. Target movement did not substantially improve detection, although studies by other research agencies have shown such an effect. One possible explanation is that the operators in the present experiment were required to continuously search a large area (75° wide and 1500 meters deep) and were therefore more or less continuously moving their devices. Under these conditions, target movement would be less conspicuous than under conditions in which the device was held more or less stationary and a target moving within the device field of view would produce an obvious disruption of a static environment. It was hypothesized that in a narrower search area dynamic targets would be more detectable than comparable static targets. The findings of subsequent BESRL research showed the differential detection of moving and static targets to be related to the search area size. These findings imply that, if movement is to be capitalized upon in detecting targets, then the search area size should be limited.

Target Type. As expected, vehicular targets were detected more frequently than were personnel targets, with little difference among devices except for the NOD. With the NOD, there was little difference between vehicular and personnel targets in percent detected. For each type of target, there was a high relationship between target detection and ambient light with far fewer targets detected at lower light levels. In general, improvement in target detection with increased ambient illumination was relatively greater for personnel targets than for vehicular targets.

Contrast. The detection of targets was found to be highly related to target contrast, with fewer low contrast targets detected. The effect of increased illumination was to reduce the relative difference between high and low contrast targets. Under low ambient illumination, target contrast was much more important to target detection than under high ambient illumination. Contrast affected performance with the NOD less than it did performance with the other devices, particularly under high illumination. The implication here is perhaps obvious, namely, that if heavy background cover reduces target-background contrast, targets will be difficult to find, and measures such as increased BOI may be indicated. Conversely, if the terrain is open, a relatively high degree of success in target detection can be expected with a single operator. Also, under high ambient illumination the NOD is not particularly sensitive to high and low contrast targets; the NOD can detect both types of target almost equally well.

Improvement of Effectiveness

Effects of Prolonged Activity. In the present experiment, operators used the devices continuously for nearly six hours, except for short breaks every half hour (five and fifteen minutes, alternately). Under these conditions, only about 1% of the players reported undue distress (due to eye strain, vertigo, nausea, etc.). In the case of the few men who reported distress, the diopter setting was found to be incorrect. A description of correct diopter adjustment procedures is contained in Appendix B.

Prolonged activity on the devices resulted in no loss in performance effectiveness for periods up to six hours, which was the limit for the experiment. Anecdotal reports from Vietnam returnees indicate that the soldier typically uses one of these devices for a short period of time and then rests. As there is equal probability that targets will appear during rest and search periods, the percent of target detection will be considerably enhanced if the device is used continuously. A work-rest cycle of thirty minutes on and five to fifteen minutes off for a six-to eight-hour watch would therefore seem to be satisfactory.

Inferences for BOI and Mix. Increasing the BOI from a single operator to a pair of operators, both covering the same area but working independently, produced a considerable increase in the percentage of targets detected (approximately 50% across devices and ambient conditions). Performance, as measured by time to detect targets, was improved only slightly by using pairs of operators. To a large extent, the improvement found by using pairs of operators was not due to the fact that the two operators were each capable of seeing different targets. Rather, they were using faulty search techniques which resulted in uneven performance. This conclusion is evidenced by the fact that a single operator, when tested again immediately after his first testing, found additional targets at about the same rate of increase as did two men simultaneously searching. There is no doubt that pairs of operators will improve performance, but this same level of performance might be obtained more economically through improved search techniques, new work methods and procedures, or better deployment of the devices.

With regard to mixing the devices, little advantage is to be gained by mixing the MINI, SS, or CSWS over using any two of the same devices. The NOD, of course, mixed with any of the other three devices, enhances performance to a much larger extent.

Training and Prior Experience. Operators were given 90 minutes of individual training consisting of three elements: instruction on the devices, including diopter setting and focusing; familiarization with the appearance of targets viewed through the device; and practice in finding the targets. It was found that 90 minutes of training of this type was sufficient and that additional training of the same kind did not enhance subsequent performance. There is, of course, no implication that additional training would not result in improved performance. On the contrary, additional training probably would improve performance, provided the training is geared to new search techniques and improved work methods and procedures.

Most of the operators in the present study were returnees from Vietnam, and most of them stated that they had some experience with the devices. Informal discussions with the operators revealed that they had received little or no training in CONUS and that training overseas had been haphazard. Their lack of knowledge, as well as misinformation, about the devices was enormous. Typically, they did not know how to make diopter adjustments or how to focus, and frequently confused the two operations. Frequently, they did not know how to perform first echelon maintenance or how to replace the battery and oscillator. Based upon observations rather than on any statistical analysis, there did not appear to be any performance differences between "experienced versus non-experienced" operators.

Search Efficiency. In order to evaluate the efficiency of search, the percentage of targets that could be seen by each man-device combination was determined. Since no search was involved in this determination, the percentage of targets seen was a function of target difficulty, the device, the ambient condition, and the perceptual capabilities of the individual operator. The fewest targets could be seen with the MINI, followed by the SS, CSWS, and NOD, in that order. The percentage of targets detected during search was divided by the percentage of targets that could be seen in order to obtain an efficiency score.

Over all ambient conditions and on all devices, the efficiency scores indicated relatively poor performance in detecting targets. On the average, only about half the targets that could be seen were actually found. Theoretically, 100% of these targets could have been detected. This result suggests that, without changing the devices at all, search effectiveness could be greatly increased. Other analyses confirmed this finding by revealing that operators were highly unreliable in their detection of specific targets.

Efficiency scores varied with the devices, the highest efficiency being with the NOD, followed by the MINI and SS, which were about equal. The efficiency with the CSWS was considerably lower than with the other devices. Considering the relatively large number of targets that could be seen with the CSWS, relatively few targets were found during search. These differences can be explained in part by device limitations and advantages and in part by the manner in which the devices were employed. For example, the field of view of the CSWS is about half that of the MINI and SS; but it has a higher magnification than the other two devices. Thus, it was possible to see a larger number of targets with the CSWS than with the MINI or SS. However, the area to be searched was large, and comprehensive coverage was more difficult for the CSWS because of its limited field of view--hence, its lower efficiency, suggesting that relative performance with the CSWS would be improved if a smaller search area were used. This hypothesis was confirmed in a subsequent experiment. These findings indicate that when the CSWS is operationally employed, search area size should be limited. This step could present a tactical complication if it is desirable to mount the CSWS on a machine gun positioned to cover a wide area.

Search Behavior. Search efficiency scores clearly indicated a failure of operators to find targets which could be seen. In order to determine the reasons for these failures in detection, aspects of the search behavior of the operators were analyzed. In the experiment, no instruction or training was given on how to search, but the players were told to use whatever technique they felt was best. In debriefing sessions, most of the players reported that they had searched the field systematically, starting search at one end of the field and then using regular right to left or left to right sweeps until the entire field was covered. The graphic records of search patterns showed that this procedure was not, in fact, followed. Other analyses showed that a substantial proportion of the targets which were not detected were never captured in the field of view of the device. An additional proportion of the targets that were not detected were in the device field of view for too short a time to have good probability of detection, suggesting that scanning was frequently too rapid. Data from subsequent experiments are being analyzed to identify other factors related to search efficiency, and additional research on new search techniques and procedures is being planned. The results of the research should make it possible to develop effective techniques and procedures which, when incorporated into training programs, will substantially improve overall system effectiveness. However, some general guidelines can be given now.

IMPLICATIONS FOR IMPROVED SEARCH PROCEDURES

For convenience of reference, a distinction is made here among "instrument scan," "eye scan," and "search." Instrument scan refers to movement of the device in order to direct it toward different portions of the terrain; eye scan refers to the examination or scrutiny of the image display; search is the general term referring to the entire instrument scan-eye scan process.

As targets in combat are frequently exposed only for short periods of time, rapid search is essential. Also, a device operator may fear that he has not detected an enemy that is approaching his position. Both these factors tend to produce very rapid instrument scanning of an area. However, even when a target is captured in the device field of view, the display must be examined for some period of time if the target is to be detected, that is, discriminated from other objects in the display. Efficient search involves a trade-off of these two factors: rapid instrument scanning and adequate eye scan or examination time. The nature of the trade-off is determined by the capabilities and limitations of the particular devices used as they interact with a number of external factors, including light, terrain, size of search area, and characteristics of the target.

<u>Light</u>. With good lighting conditions, either natural or provided by some artificial illumination system, the time required for eye scan is minimized and, correspondingly, instrument scanning can be performed more rapidly. However, as the light decreases, more lengthy eye scan is necessary and the rate of instrument scanning should correspondingly decrease.

<u>Terrain</u>. For open terrain, the time required for eye scan is relatively small and instrument scan can be rapid. As terrain clutter increases, the amount of eye scan should increase and rate of instrument scan correspondingly decrease.

<u>Size of Search Area</u>. As the search area size increases, adequate coverage necessitates rapid instrument scan and little eye scan time. The requirement for rapid search of a large area may therefore very easily exceed the individual's ability to examine adequately the image display, with a resulting drop in probability of target detection. No guidelines can be provided for search area size as this will be a

function of such other factors as light and terrain. Search area size must therefore be empirically determined, based upon previous experience in similar situations.

Nature of Target. Obviously, large targets are more easily detected than small targets. However, target difficulty is also affected by the similarity of the target to other objects in the terrain. For example, a kneeling man would be very hard to detect in terrain covered with tree stumps. Search, therefore, should be adjusted according to the characteristics of the targets expected, as well as to the nature of the terrain involved. Also, moving targets seem to be more easily detected than stationary targets when the area to be searched is small, but not when the area is large. Therefore, if it is anticipated that targets will be moving, a smaller search area size may prove profitable.

Instruction and training of device operators on these general principles of search should considerably improve their effectiveness. More adequate training should also be given on proper procedures to be followed for diopter adjustment and focusing, and it should be made clear that these two operations have distinctly different functions. The training procedures used in the present experiment were simple and could easily be incorporated, with minor changes, in a training program that could be conducted in a rear area by a company commander in Vietnam.

In the present research, operators differed greatly in their ability to find targets. Some of these differences can be reduced by more effective training, by better knowledge of the device, and by improved search techniques and work methods. However, individual differences in ability are probably of sufficient magnitude to justify the use of a simple performance measure by a company commander to rank potential device operators on their proficiency with a device. This measure could follow the training program outlined above. With this information, subsequent assignments could be made considering proficiency as well as criticality of mission and military expediency.

TECHNICAL SUPPLEMENT

SEARCH EFFECTIVENESS WITH PASSIVE NIGHT VISION DEVICES

EXPERIMENTAL PROCEDURE AND DETAILS OF RESULTS

The procedures and special experimental techniques developed for BESRL's on-going research on search effectiveness with passive night vision devices are described in considerable detail. Further informational background is made available in reproductions of the briefings and instructions (Appendix A) prepared for the player personnel (subjects) participating in the experiment, and in the step-by-step procedures prescribed for the field testing (Appendix B).

The second part of the Technical Supplement presents in greater detail than in the body of the report the results upon which findings were based.

EQUIPMENT

Night Vision Devices Tested

The experiment dealt with image intensifiers of four different types: the Miniaturized Night Vision Sight, AN/PVS-3 (MINI); the Small Starlight Scope, AN-PVS-2 (SS); the Crew Served Weapon Night Vision Sight, AN/TVS-2 (CSWS); and the Night Observation Device, Medium Range, AN/TVS-4 (NOD).

The Data Acquisition System

The data acquisition system has three components: 1) the tripods which support the universal device platforms (UDPs) and the night vision devices; 2) the universal device platforms; and 3) the electronic control and data recording console. Nine heavy-duty tripods are used in line, each tripod being set into concrete for stability. The UDPs each consist of a metal casing attached to the tripod head, the night vision devices being attached to the UDP (Figure 1). The UDP rotates with respect to a fixed base and is adjustable for elevation. Each UDP contains two shaft encoders, one for azimuth and one for elevation, which indicate to within 0.1° the orientation of the instrument (Figure 2). Each UDP also contains a "trigger" microswitch which the player presses when he acquires a target. These microswitches are designed and located so that their use does not interrupt searching or disturb orientation of the device. Output from the microswitch and shaft encoders is transmitted by cable to the data recording console.

The electronic control and data recording console (Figure 3) is van-mounted and contains a monitoring-control panel and a recorder panel. On the monitoring-control panel are a magnetic tape unit,

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numerical displays (NIXIE[3] tubes) for visual presentation of azimuth and elevation of selected subject stations on a real-time basis, and a number of selection buttons. Information recorded on the magnetic tape includes the beginning and end of target presentation, player number and the azimuth and elevation of the device used (sampled five times per second), and any responses by a player. A time base is provided by tape speed. Thus, both target acquisition responses and fine-grain recording of search behavior are on the tape and extractable by computer. The recorder panel contains a digital recorder which provides a graphic hard-copy display of the search behavior, target coordinates, and responses of any selected player, on a near real-time basis.

Ancillary Equipment

The communication system includes land-line telephones between control and personnel targets; radio communication between control and vehicular targets; telephone lines between control, engineer in van, and target monitor; and a two-way speaker system between control and the player cubicles.

Photometric readings were obtained with a Gamma Scientific Corporation model 2020 photometer[4], with S-11 photocathode and cosine-filter which gave an integrated reading, in footcandles, of illumination from the upper hemisphere. Readings were taken at regular intervals throughout the experiment.

Terrain

The terrain was part of the Hunter Liggett Military Reservation. In selecting the terrain, many factors had to be considered. First, the experiment required terrain of considerable size, suitable for a wide variety of experimentation. The terrain selected permitted the use of a search area approximately 75° wide and over 1500 meters deep. Second, the purpose of the study was to determine the search effectiveness, for operational use, of selected devices. The terrain therefore had to be complex in order to provide a realistic search situation. Search effectiveness cannot very well be determined by measuring the probability of detection of a black dot on a white background (unless, perhaps, one is interested in arctic conditions), as this task is primarily a perceptual problem and little discrimination is required. A realistic search problem requires the finding of

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[3] Commercial designations are used only for precision in describing the experiment. Their use does not constitute indorsement by the Army or by the Behavior and Systems Research Laboratory.

[4] See footnote 3.

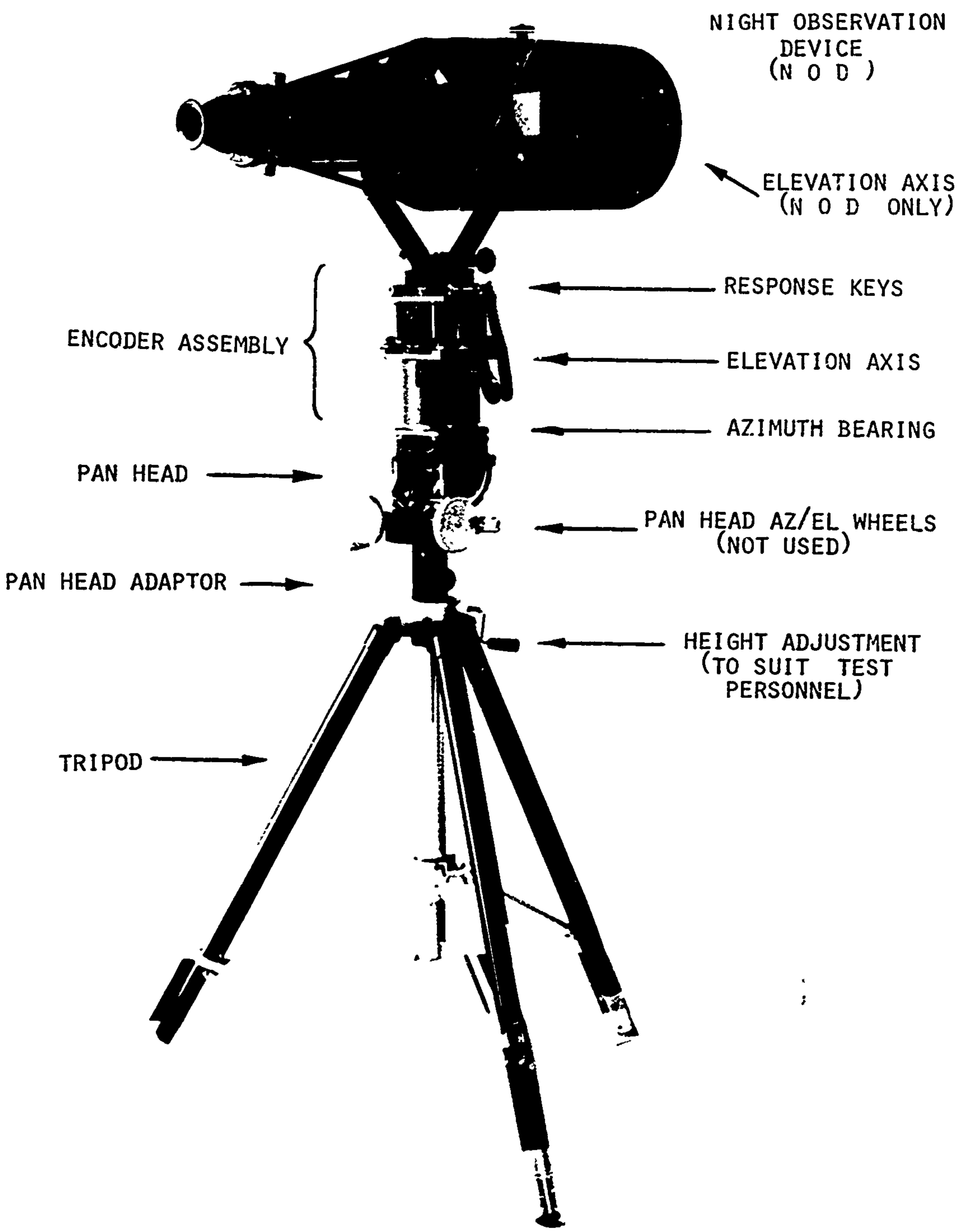

Figure 1. Universal Device Platform with Mounted Night Observation Device, Medium Range

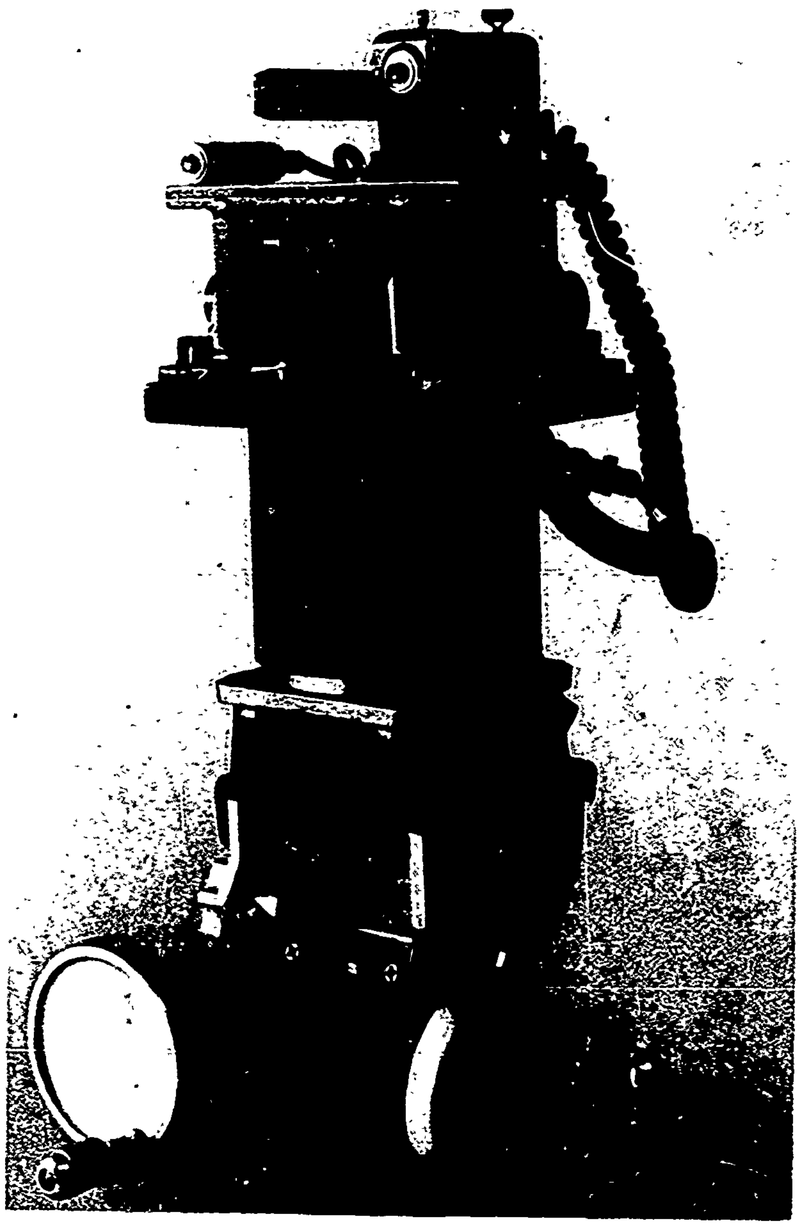

Figure 2. Enlarged View of Shaft Encoder Assembly Portion of UDP (Shows Response Buttons)

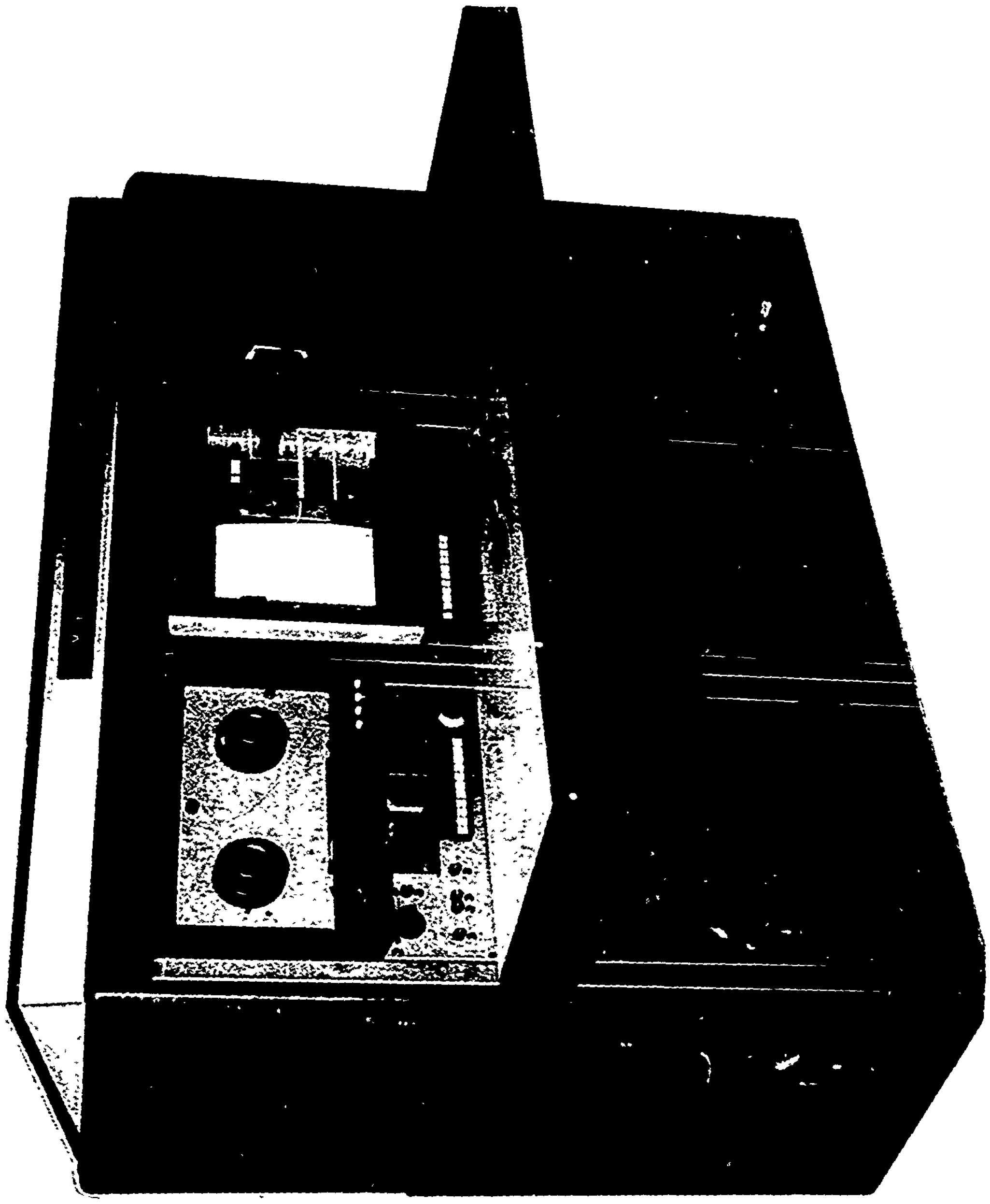

Figure 3. Monitoring-Control Console

an object of interest and its discrimination from other similar objects (typified by the problem of finding the nut you have dropped in the gravel while repairing your carburetor). The area selected was flat to mountainous, bisected by a road, traversed by ravines and streams, with some large open grassy areas and some areas heavily cluttered with trees, brush, and rocks. Third, because the devices being tested initially were of the light intensification type, good control of illumination was essential. The test area was surrounded by mountains, the nearest town of any size (though small) being some 30 miles distant. Skyglow was therefore effectively eliminated. Additionally, the terrain had a general north-south orientation, the moon passing over the terrain roughly from right to left. Thus, when testing under moonlight, targets were not frontlighted during one portion of the session and backlighted during a later portion. (Previous research has shown that the probability of detection changes considerably for front versus back lighting.) Figure 4 shows a portion of the terrain. Figure 5 shows the back-up area and test cubicles as seen from the target area.

Targets

A total of 36 target locations was used in the testing session. All targets could be seen by the unaided eye during daylight. Targets at each location were presented once in a dynamic and once in a static mode, giving 72 target presentations per evening in the primary experiment. The 36 targets were of two types: 24 personnel and 12 vehicular. Four types of vehicle were used: ¼-ton truck, 2½-ton truck, armored personnel carrier (M-113), and tank (M-60). The personnel targets were soldiers dressed in fatigues, appearing either singly or in groups of two or three men. The targets were of varying difficulty and were distributed throughout the terrain at distances of 100-1200 meters from the test stations. Targets were located in three bands: 100-350 (near-distance); 350-800 (mid-distance); and 800-1200 far-distance). Contrast was manipulated by placing targets against suitable backgrounds--silhouetted against a tree line (low contrast) or against an open grassy area (high contrast)--but no attempt was made to rigorously define or measure target-background contrast. Placement of targets was carefully controlled so that target visibility remained constant for a given evening, e.g., changes in moon angle did not throw a shadow on a target during one part of a night's run. A complete description of the targets appear in Table 1.

Ambient Illimination Conditions

Testing was conducted under three ambient illumination conditions: starlight, one quarter to half moon (half moon), and three quarter to full moon (full moon). The average photometric readings (in footcandles) which were obtained under each of these conditions are given below.

Starlight: 8.4×10^{-5} to 1.1×10^{-4}; mean = 9.7×10^{-5}.

Half Moon: 4.4×10^{-4} to 2.1×10^{-3}; mean = 1.4×10^{-3}.

Full Moon: 4.8×10^{-3} to 1.4×10^{-2}; mean = 1.1×10^{-2}.

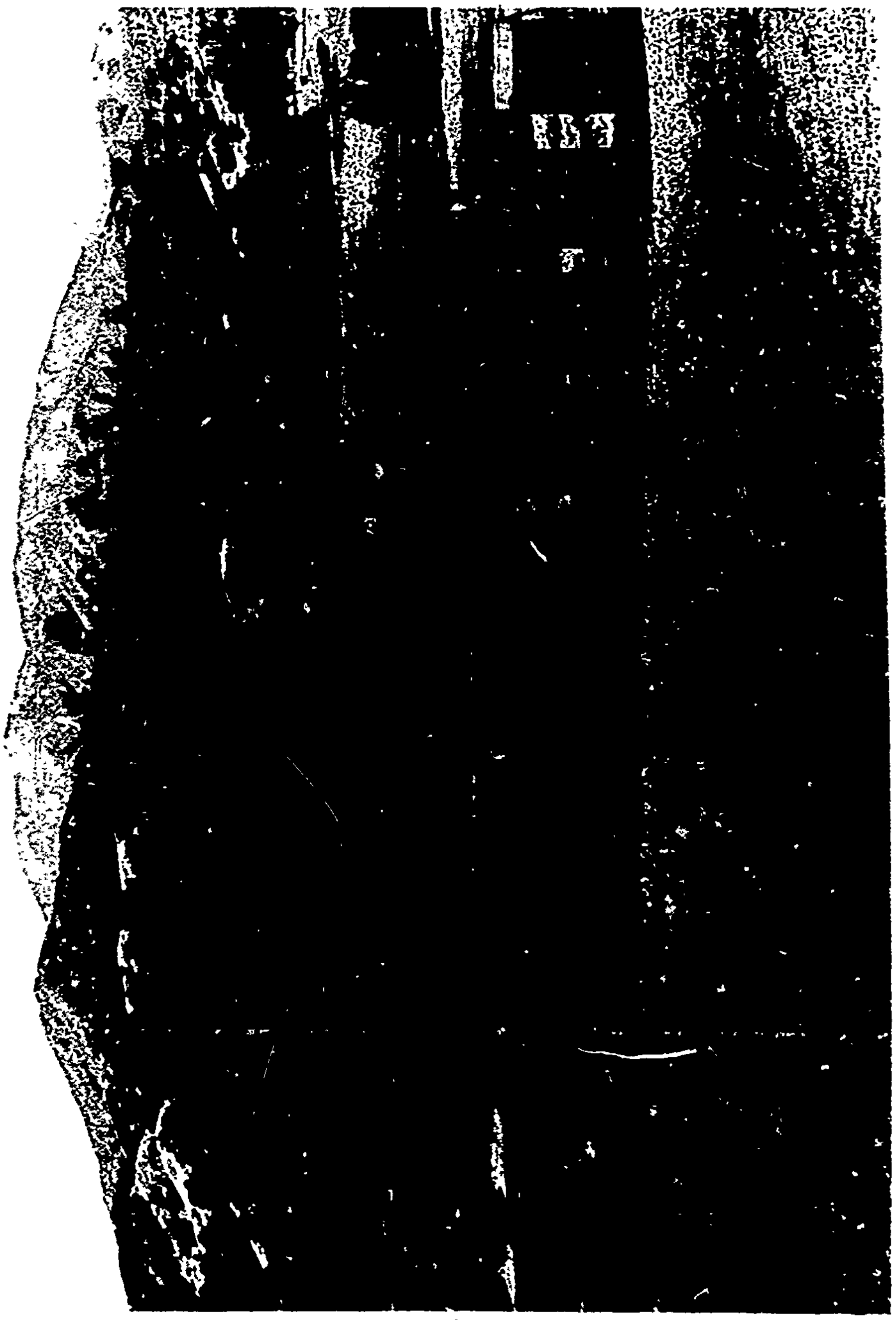

Figure 4: Left Half of Terrain Forming the Target Area (Shows Player Test Cubicles in Foreground)

BESRL / CDCEC FIELD EXPERIMENTATION SITE

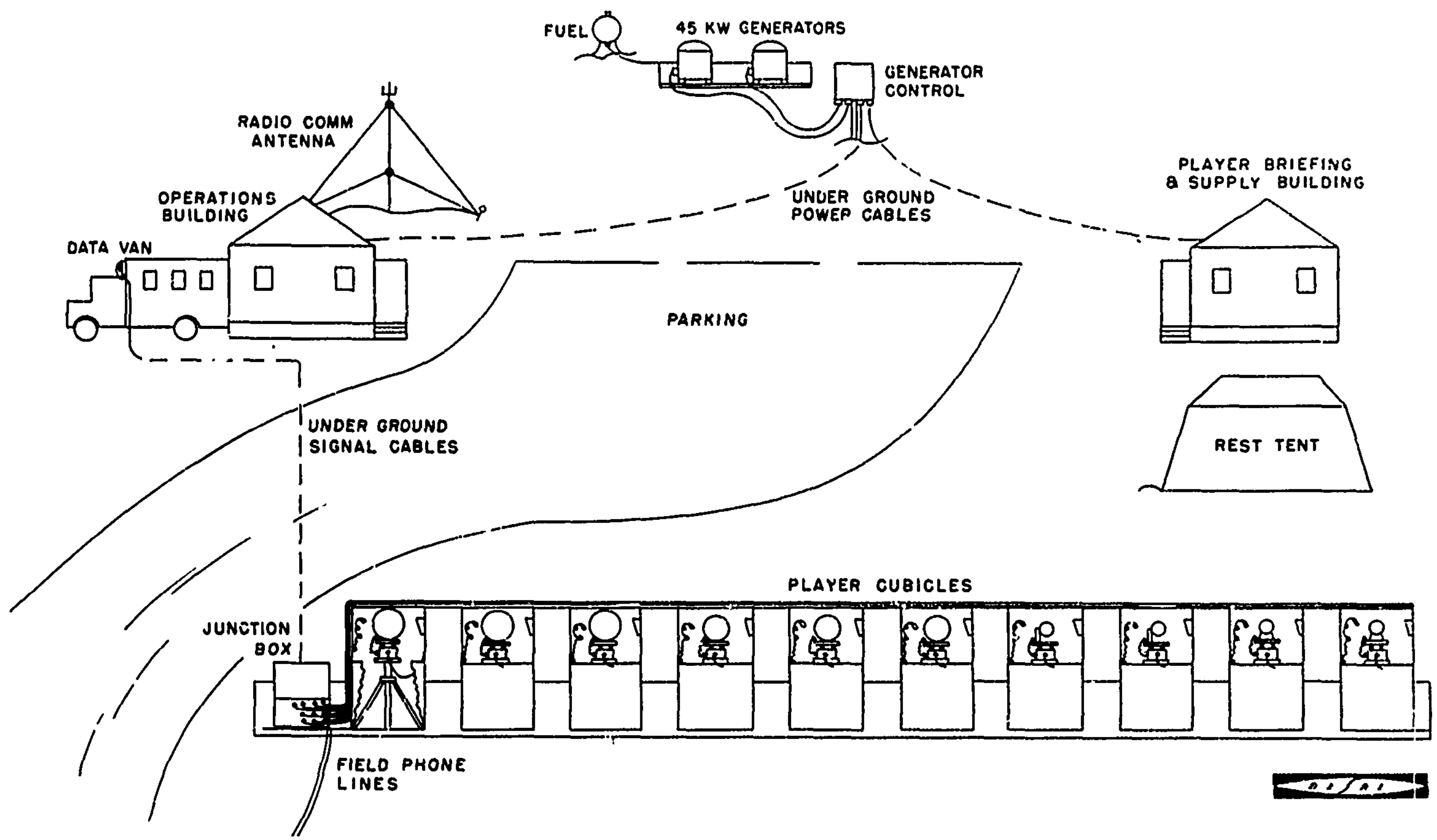

Figure 5. Schematic Drawing of Test Control Center Looking Back from Terrain

Table 1

DESCRIPTION OF TARGETS

Target[a]	Type	Azimuth[b]	Elevation[b]	Slant Distance[c]	Range[d]	Contrast
12A	M60 Tank	+ 13.1	+ 1.9	922	Far	High
3A	1 Man	+ 7.7	- 3.4	270	Near	Low
5A	1 Man	- 32.4	- 3.8	515	Middle	Low
8A	3 Men	+ 28.0	+ 2.9	1004	Far	High
10A	APC M113	+ 28.2	- 3.3	211	Near	High
2A	1 Man	+ 7.2	- 5.5	108	Near	Low
7A	2 Men	- 34.8	- 1.3	704	Middle	High
11A	5 Ton	- 13.9	- 1.6	590	Middle	High
4A	1 Man	+ 19.6	- 0.9	360	Middle	Low
9A	Jeep M161	- 25.4	- 4.2	299	Near	High
1A	1 Man	- 20.2	- 4.5	272	Near	High
6A	1 Man	+ 3.3	- 2.3	485	Middle	High
12B	M60 Tank	+ 19.7	+ 2.3	977	Far	High
3B	1 Man	- 16.1	- 2.7	534	Middle	High
5B	1 Man	- 26.6	- 1.5	659	Middle	High
8B	3 Men	- 18.1	- 0.0	643	Middle	Low
10B	APC M113	- 21.8	+ 3.5	938	Far	Low
2B	1 Man	+ 16.3	- 4.4	156	Near	High
7B	2 Men	- 12.5	+ 1.9	870	Far	Low
11B	5 Ton	+ 5.6	- 1.9	518	Middle	High
4B	1 Man	+ 28.1	- 2.2	269	Near	High
9B	Jeep M161	- 9.9	- 3.9	251	Near	High
1B	1 Man	- 33.7	- 4.1	156	Near	Low
6B	1 Man	- 24.0	- 3.0	538	Middle	High
12C	M60 Tank	- 20.9	- 0.5	710	Middle	High
3C	1 Man	- 8.7	- 3.8	282	Near	High
5C	1 Man	- 4.7	- 0.4	666	Middle	Low
8C	3 Men	- 5.5	+ 0.5	765	Middle	Low
10C	APC M113	+ 26.1	+ 3.3	1091	Far	High
2C	1 Man	- 9.2	- 5.1	97	Near	High
7C	2 Men	+ 27.6	+ 1.5	886	Far	High
11C	5 Ton	+ 8.0	+ 2.4	1132	Far	Low
4C	1 Man	+ 26.8	- 3.3	181	Near	High
9C	Jeep M161	+ 4.1	- 3.2	417	Middle	Low
1C	1 Man	- 29.8	- 4.8	165	Near	High
6C	1 Man	+ 12.6	+ 1.5	831	Far	High

[a] A block of targets (12-6) represents one scenario. Targets within a scenario are shown in order of presentation. Each target was presented twice, once in a static and once in a dynamic mode, in counterbalanced order. Order of presentation of scenarios was also counterbalanced.

[b] Target azimuth and elevation readings in degrees from the middle booth. Plus or Minus reflects displacement from the calibration zero point: right or up (+); left or down (–).

[c] Slant Distance to nearest meter.

[d] Range denotes distance category: Near 100-350, Middle 351-800, and Far 801-1400 meters.

TESTING PROCEDURE

Subjects

The subjects--or players--were 123 enlisted men from the Experimentation Battalion (Armor), Camp Roberts, California.

Nine players were tested per night (two or three on each of the four devices). The total number of players tested on each device under each illumination condition is shown in Table 2.

Table 2

NUMBER OF PLAYERS TESTED UNDER VARYING CONDITIONS OF AMBIENT LIGHT

	Ambient Light Level			
Device	Starlight	Half Moon	Full Moon	Total
MINI	11	12	9	32
SS	11	12	9	32
CSWS	12	10	9	31
NOD	11	9	8	28
Totals	45	43	35	123

Orientation of Players

When players arrived at the test site, they were brought into a briefing tent without being permitted to study the terrain. No players had had prior experience on the particular terrain used. Designated military personnel explained to the players the importance of the research. A civilian scientist then explained their role as players and described what they would be doing during the course of the night. Players were then taken into the Experimental Control Center and the equipment and functions were described to them. These briefings had two purposes: first, to increase the players' interest and involvement in the experiment and, second, to explain how and why their performance with the devices would be monitored throughout the evening. This combination of approaches was effective in eliciting their cooperation and sustained participation.

Training

Following the briefings, players were assigned to specific devices and training was begun. The training session had three purposes: 1) to instruct the player in the use of his device; 2) to teach him the appearance of targets when viewed through a night vision device; and 3) to allow him to develop facility in rapid detection and simulated shooting of the targets. Training did not commence until at least the End of Evening Nautical Twilight (EENT), with the sun 12° or more below the horizon. The training session was conducted by the Test Director, with the engineer at the monitoring-control console and nine instructors who assisted the players individually. The Test Director first read a prepared script of general instructions. When the instructions became specific to the device, the individual instructors instructed the players, reading from a prepared script. The instructions included tripod height adjustment, diopter adjustment, objective lens focusing, limits of the search area, and procedures to be followed in shooting the targets. No instructions or training on search techniques were given, but the players were told that during testing each should use whatever technique was best for him.

When all adjustments were made and the players understood how to use the device, the second phase of training began. Five targets were presented, one at a time. Prior to presentation of each target, the players were told the type of target, its location, and that it would be lighted. The players were instructed to find the light and to shoot it. After all players had found and shot the target, the light was extinguished and the players were instructed to study and shoot the target again if they could see it. The engineer at the monitoring-control console compared player responses with a catalog of actual target locations and informed the Test Director which players were having difficulty in finding the targets or were not following proper procedures. When all players had successfully responded to each of these five targets, an additional eight targets were presented, one at a time. For these targets, the players were not told the target location, but the target again was lighted. After most players had found and shot the lighted target, the light was extinguished and the players were instructed to study and shoot the target again if they could see it. Players having difficulty were assisted by their instructors.

The purpose of the third phase of training was to provide practice in rapid acquisition of targets so that subsequent performance during testing would not be influenced by additional learning. Thirteen targets were presented, following the same procedure as during testing, and no assistance, either by lights or instruction, was given. At the conclusion of training, players were given a 15-minute rest prior to the beginning of testing.

Total training time was approximately 90 minutes (15, 30, and 45 for PARTS 1, 2, and 3, respectively). This highly structured training session had been found in previous research to be necessary for adequate training in a reasonable amount of time. While training was performed on the same terrain used for testing, the practice target locations were different from the experimental target locations.

Testing

Testing did not commence until after the End of Evening Astronomical Twilight (EEAT), when the sun is 18° or more below the horizon, and was terminated prior to the Beginning of Morning Astronomical Twilight (BMAT), before the sun approaches 18° below the horizon. Testing was scheduled so that the ambient illumination on any given night remained relatively constant--for example, on a half-moon night, data were collected only when the half moon was exposed. When testing was conducted under moonlight conditions, data collection did not commence until the moon had ascended to 25° above the eastern horizon and was terminated before the moon descended beyond 25° above the western horizon. These procedures minimized the ambient illumination changes during any given evening.

The testing phase of the experiment was divided into two parts. The first part was to determine the ability of players to find targets through search. The second part was to determine the ability of each man-device combination to see targets without search.

Search. Players were required to search the terrain continuously for six periods of 30 minutes each. During each period, 12 targets were exposed for two minutes per target, with approximately 30 seconds between target presentations. At one-half hour intervals, players were given a five-minute break in place. At one-hour intervals, they were given a 15-minute break, during which they were brought into the tent where they could smoke, warm up, and get coffee. During this break the targets were relocated.

In each block of 24 targets, each target was presented twice, once in dynamic and once in static mode, that is, 12 targets were presented, some moving and some stationary. After a short rest break for the players, the twelve targets were presented again, in the same location but in reversed mode. All targets moved parallel to the line of player cubicles, that is, across the line of sight of the players as they searched the field. Personnel targets moved at a walking pace and vehicular targets at approximately three or four miles per hour. The movement of each target was 1° of visual arc, the actual length traversed being adjusted according to the distance of the target from the players. Three basic sequences (scenarios) of target presentations were used, with two movement subsequences (subscenarios) under each. Each scenario contained targets of all types, distances, and contrasts. Order of scenarios and movement subscenarios was systematically varied to counterbalance sequential effects. For the most part, only one target was presented at a time (a multiple-man personnel target being defined as a single target), but three times in each subscenario two targets (in different locations) were presented simultaneously to reduce the possibility that players would learn that only single targets were presented. In this case, however, only the primary target was scored. To prevent players from using vehicle engine noise as a cue, three times in each subscenario one of the vehicular targets which was not exposed would run its engine for 30 seconds.

For the entire evening's run, targets were continuously observed by the target monitor on the test line. The monitor was equipped with a NOD and was thoroughly familiar with all target locations and the order of the scenarios being used on a given night. His primary responsibility was to verify that targets were up and down at the correct times, in the correct locations, and in the correct movement modes. In most cases, a one-word verification immediately followed target report. This procedure was utilized, however, to maintain discipline and responsiveness of target personnel. Additional responsibilities of the monitor included reporting of light security violations, improper concealment of targets, and changes in ambient illumination and weather conditions.

Player behavior was continuously monitored by the instructor assigned to each player, by the training NCO, and by a civilian scientist also on the test line. In addition, an engineer at the monitoring-control console continuously monitored visual displays (NIXIE tubes) showing real-time azimuth and elevation of each instrument to insure that all players were searching and following correct procedures.

For purpose of analysis, a player response was defined as a "hit" when the azimuth and elevation of the instrument were within $\pm 3^{\circ}$ of the actual target location. The target detection data reported are based on this definition.

See. Upon completion of the search phase of testing, the final 12 targets were presented again to determine the ability of each man-device combination to see targets when no search was involved. On each trial, the target turned a light on himself and the players were told the target location and type. Players were instructed to find the lighted target. After the light was extinguished, they were to continue to watch the target (if they could see it) and to fire on it as soon as it started to move into defilade. Targets moved into defilade at varying times (unknown to the players) after the light was extinguished: 20 seconds for Near targets, 40 seconds for Mid targets, and 60 seconds for Far targets. The player was scored as having seen the target if he fired while the target was moving into defilade or within eight seconds of target disappearance.

RESULTS

Detailed results of the present experiment on the performance effectiveness of selected passive night vision devices deal with 1) the influence of critical environmental-target-terrain factors on search effectiveness, and 2) human and employment factors related to improvement of effectiveness. Interactions between factors in the two categories are also considered. Environmental-target-terrain factors discussed are: ambient illumination, distance (range), target mode (dynamic vs static), target type (personnel vs vehicular), and target-background contrast (high vs low). Two measures of effectiveness are used in the search effectiveness experimentation: percent of targets detected and the time required to detect these targets. Human and employment factors considered are: prolonged activity, training, Basis of Issue and Mix, search efficiency, and search behavior.

Search Effectiveness

The devices employed were developed to accomplish different but related military operations. Their effectiveness is dependent upon a number of variables related to the target-terrain situation and environmental conditions. Based upon previous research and pilot studies, a number of these salient factors were selected to allow for both performance evaluation of the individual device and for comparisons among devices under varying conditions.

Effect of Ambient Light on Target Detection. The percentage of targets detected was calculated as a simple ratio of the number of targets detected divided by the total number of targets presented. A detection was defined as shooting a true target within a narrow error band--within three degrees of the center of device reticle. (Earlier BESRL research at Fort Benning, Georgia, had indicated no practical differences in detection and recognition responses for either percentage detections or time to detect. Therefore, only detection responses were used in the present study.)

Table 3 shows percent detection with each device under each of the illumination conditions.

Table 3

PERCENT TARGET DETECTION UNDER VARYING CONDITIONS OF AMBIENT LIGHT

	Ambient Light Level		
Device	Starlight	Half Moon	Full Moon
MINI	20	30	45
SS	24	36	52
CSWS	19	29	36
NOD	42	46	65

As expected, performance with all devices improved markedly with increased illumination, although the degree of improvement is much more dramatic for the smaller devices such as the MINI (125% improvement from starlight to full moon) than for the NOD (55% improvement from starlight to full moon). The lack of large differences in performances with the MINI, the SS, and the CSWS should also be noted, the relative ranking of performance (high to low) being SS, MINI, and CSWS. The relatively poorer performance with the CSWS is surprising as this device has a larger objective lens and higher magnification than the other two devices and might be expected to produce better overall performance. However, performance with the NOD was, as expected, higher than with the other devices, most notably for the lower levels of illumination. The values given in Table 3 represent average performance across all operators. Individual operators differed greatly in the ability to detect targets. Data from later research are being analyzed to determine what characteristics of the operators or their techniques of search are related to these differences in performance.

Effect of Ambient Light on Target Detection Time. Target detection time was determined by the number of seconds the operator took to find and shoot the target. Time began as soon as the target was in position and ended when the target had been shot. Table 4 shows mean time required to detect the targets with each device under the three illumination levels.

Table 4

TARGET DETECTION TIME UNDER VARYING CONDITIONS OF AMBIENT LIGHT (In Seconds)

	Ambient Light Level		
Device	Starlight	Half Moon	Full Moon
MINI	52	51	45
SS	51	48	42
CSWS	58	54	52
NOD	52	47	45

About 50 seconds, on the average, was required to detect the targets. Operationally, this could be considered a relatively long time as actual targets in combat frequently are exposed for much shorter time periods. The data show that there was relatively little difference among the devices in the speed with which targets were found, with the possible exception of the CSWS. The data also show that time to detect a target was much more affected by ambient light than by device type.

Table 5 gives cumulative frequency distributions, by device and by ambient illumination level, of the time required to find the targets. Distributions were highly similar for all devices, with a shift about the mean as light level increased. On the average, very few targets were detected within the first 15 seconds, irrespective of device.

Table 5

CUMULATIVE PERCENTAGE OF TARGETS DETECTED
(By 15-second Blocks)

Ambient Light Level	Device	Time in Seconds 0-15	16-30	31-45	46-60	61-75	76-90	91-105	106-120
STARLIGHT	MINI	15	30	44	60	77	85	92	100
	SS	18	36	47	62	77	85	90	100
	CSWS	13	27	43	54	65	77	87	100
	NOD	20	34	45	59	74	85	91	100
HALF MOON	MINI	18	34	49	60	71	85	91	100
	SS	20	39	56	66	77	88	96	100
	CSWS	16	31	44	60	73	84	90	100
	NOD	20	39	54	68	76	86	93	100
FULL MOON	MINI	23	42	58	68	82	90	94	100
	SS	26	44	62	76	86	91	98	100
	CSWS	14	32	49	63	76	82	91	100
	NOD	22	45	58	71	82	91	97	100

Effect of Distance. Table 6 shows how the percent detection was affected by distance for each device under the three illumination conditions. Percentages were computed separately for each device for each illumination condition by summing the number of hits for a given distance and dividing by the total number of targets presented at that distance. The three distances involved were near (100-350 meters), mid (350-800 meters), and far (800-1200 meters).

The results clearly indicate sharp losses for each device as a function of distance. For example, performance on the MINI under starlight condition went from 30% detection for near distances to 11% for far distances. An unequal number of vehicular and personnel targets were used and most of the vehicular targets and very few personnel targets were at the far half of the range, the reverse being true for the near half of the range. Had an equal number of personnel and vehicular targets been placed in the two halves, the percentage of far targets detected would have probably been smaller and the percentage of near targets detected larger. Thus the difference (e.g., 11% - 30% for the MINI under starlight) would have been more extreme.

The data also clearly show the sharp gains for each device as a function of increased ambient light. For example, performance on the MINI for near distances went from 30% detection for starlight conditions to 64% detection for the full-moon condition.

In general, performance with the MINI, SS, and CSWS for near targets was substantially affected by increased ambient light, in contrast to performance with the NOD, which was only slightly affected. For far distances, the same proportionate increase also appeared for those three devices. However, performance with the NOD also increased dramatically with far distances.

On the average, for each ambient illumination condition and for each device (except the NOD under half moon and full moon), ratio of the performance at near and far distances was about 3 to 1.

Effect of Target Mode--Static vs Dynamic. Each target, based on a random schedule, was presented twice, once in static and once in dynamic mode. The results are shown in Table 7. For all devices, there were no differences in the percentage of moving and stationary targets detected under the starlight condition, and only slight performance differences favoring the moving targets for the full-moon condition. This finding is surprising, as other reports have shown that moving targets have a considerably higher probability of detection.

Effect of Distance and Target Mode. The data were analyzed to determine whether movement assisted in the detection of more distant targets and not in the detection of the relatively easier near targets (Table 8). Again, there was little difference due to target mode, irrespective of distance. One possible explanation lies in the size of

Table 6

PERCENT TARGET DETECTION BY DISTANCE AT VARIED AMBIENT LIGHT LEVELS

Device	Distance	Starlight	Half Moon	Full Moon
	NEAR	30	47	64
MINI	MID	17	25	42
	FAR	11	12	22
	NEAR	37	54	68
SS	MID	21	31	55
	FAR	11	18	24
	NEAR	29	40	50
CSWS	MID	16	28	36
	FAR	9	16	14
	NEAR	59	55	67
NOD	MID	41	48	75
	FAR	19	31	47

of the area to be searched. In the present study, the players were continuously searching a large area (75° by 1500 meters) and were therefore more or less continuously moving their devices. Under these conditions, movement of the target would be less conspicuous than under conditions in which the device was held relatively stationary, and a target moving across the device field of view would produce an obvious disruption of a static environment. (In a follow-up study, the area was narrowed to 25°. Initial examination of the data on search performance with a 25° search area indicates that more moving than static targets were detected; i.e., differential detection of moving and static targets is related to the search area size.)

Table 7

PERCENTAGE TARGET DETECTION BY TARGET MODE--STATIC vs DYNAMIC

	Ambient Light Level					
	Starlight		Half Moon		Full Moon	
Device	Stat	Dyn	Stat	Dyn	Stat	Dyn
MINI	21	19	28	32	42	49
SS	25	24	35	38	48	56
CSWS	20	18	28	30	32	40
NOD	41	42	42	51	61	69

Table 8

PERCENT TARGET DETECTION BY DISTANCE AND TARGET MODE

		Ambient Light Level					
		Starlight		Half Moon		Full Moon	
Device	Distance	Stat	Dyn	Stat	Dyn	Stat	Dyn
	NEAR	30	30	41	53	61	66
MINI	MID	19	15	25	26	37	49
	FAR	11	10	13	11	21	23
	NEAR	36	38	55	54	66	70
SS	MID	23	19	30	32	48	62
	FAR	12	9	13	23	22	26
	NEAR	31	28	38	42	44	55
CSWS	MID	16	16	26	30	32	41
	FAR	11	7	18	15	11	17
	NEAR	55	63	48	62	58	75
NOD	MID	43	38	44	51	73	77
	FAR	19	19	29	34	47	47

Effect of Target Type--Vehicular vs Personnel. Table 9 shows the percent of vehicular and personnel targets detected. As previously noted, an unequal number of vehicular and personnel targets were used. Preliminary research had indicated an extremely high probability of detection for near vehicular targets and low probability for far personnel targets. Optimal use of resources dictated placement of most vehicles at the mid-distance and far-distance and personnel at near-distance and mid-distance. Direct comparison of detections for vehicular and personnel targets was therefore difficult.

Table 9

PERCENT TARGET DETECTION BY TARGET TYPE--VEHICULAR vs PERSONNEL

	Ambient Light Level					
	Starlight		Half Moon		Full Moon	
Device	Veh	Pers	Veh	Pers	Veh	Pers
MINI	30	15	45	23	58	40
SS	35	19	52	29	59	49
CSWS	28	15	37	25	42	33
NOD	51	38	61	39	70	63

The data are meaningful, however, if percent detections are examined separately for personnel and vehicular targets. For example, detection of personnel targets improved considerably as a function of ambient light, going from 15% detection to 40% for the MINI under starlight and full-moon conditions, respectively. Detection of vehicular targets likewise improved from 30% to 58% for the MINI under starlight and full-moon, respectively. In general, both the vehicular and personnel target detection scores increased as a function of increased illumination, with personnel target detection increasing more than vehicular target detection.

It will be recalled that comparison of overall performance of the devices (Table 3) revealed relatively small differences between the MINI, SS, and CSWS, the general ranking of performance (high to low) being NOD, SS, MINI, CSWS. Detection of personnel and vehicular targets, analyzed separately, maintained the same relationship, indicating that the previously reported differences among the devices were not a function of target type.

Effect of Contrast. Target-background contrast was estimated for this study as either high or low, contrast being dependent upon whether the target was in open view or whether trees and high brush were in the immediate background. The results are shown in Table 10. In accordance with expectations, high contrast targets were detected more frequently with all devices under all illumination conditions. The difference is on the order of 2 or 3 to 1 for starlight conditions, and less than 2 to 1 for full-moon conditions, the difference being slightly less for the NOD than for the other devices.

Table 10

PERCENT TARGET DETECTION BY CONTRAST--HIGH vs LOW

	Ambient Light Level					
	Starlight		Half Moon		Full Moon	
Device	High	Low	High	Low	High	Low
MINI	25	10	38	13	52	32
SS	31	10	44	22	60	38
CSWS	24	10	34	20	42	23
NOD	51	24	54	31	68	59

Improvement of Effectiveness

The previous section described the effects of critical environmental-target-terrain factors on search performance. In general, the performance observed allowed considerable room for improvement. Analysis of the human and employment factors as related to improvement of effectiveness bears on such problems as how long an operator can use the devices continuously, the effect of training and experience, the effect of increased Basis of Issue and Mix of devices, the relationship between seeing and finding targets, the reliability of operators, and how the operator searches the target area.

Effects of Prolonged Activity. One of the most critical operational questions is how long a soldier can use these devices before his performance is degraded. For the researcher, the same question had to be answered so that he would know whether it was feasible to combine data from early and late evening performance--whether the operator's overall performance during a test session was biased by either fatigue or lack of vigilance late in the session.

The players were given 90 minutes of instruction and practice on their devices. Following a 15-minute break, the players were in continuous search activity except for short breaks every 30 minutes. Therefore, the total amount of time (with short breaks) the player was with his device was about five and one-half hours. During this period, the players were monitored constantly to insure that any decrement in performance found could not be attributed to an experimental artifact.

Two criteria were employed for determining the effects of prolonged activity: 1) the number of players eliminated due to illness, and 2) comparison of player performance during the first, mid, and final blocks of targets. The operator's performance on the 72 targets was analyzed by first 24, second 24, and third 24 targets.

Only two players failed to complete a testing session, both because of complaints of headaches, nausea, etc. Following some simple first aid, they were debriefed and their devices inspected. From the inspection and debriefing it was discovered that both players had made gross errors in diopter adjustment. In routine debriefings, other players were asked if they were tired or if they could continue and still perform at the same level. The common response was that they could continue, but that they were getting bored. In regard to the first criterion, therefore, the results showed that soldiers could, and did in fact, perform for a prolonged period (5-1/2 hours) without undue distress.

The data were analyzed to determine whether the second criterion (a stable level of performance) was also satisfied. Results are shown in Figures 6 and 7 for percentage of targets detected (for starlight and full moon, respectively), and in Figures 8 and 9 for the comparable detection times. From inspection of these figures, two points are obvious: First, the devices differ in overall performance, as was previously shown. Second, no consistent tendency exists toward degradation in performance with increasing time on device for either percent detection or detection time. Properly motivated men can effectively use these devices for up to five and one-half hours, and probably longer.

Training. About 75% of the players employed in the study were returnees from Vietnam. Most of them stated that they had some experience with the devices under study. In informal private and group discussions with the civilian research scientists, the players indicated that they had received no training on the devices in CONUS and that they received no formal training overseas. Their lack of knowledge, as well as misinformation, about the devices was enormous. Typically, they did not know how to make diopter adjustments or how to focus, and frequently confused the two operations. They did not know how to perform first echelon maintenance and often did not know how to replace the battery or oscillator. Some did not know the location of the On-Off switch.

As described in the report, the players were given 90 minutes training: 15 minutes of instruction on the instrument, including how to make diopter adjustments and how to change focus; 30 minutes of familiarization with the appearance of targets viewed through the devices; and 45 minutes of practice in finding targets. No instruction or training was given on how to search. The players were simply given the limits of the search area and told to find the targets using whatever they felt was the best technique. In debriefing sessions, most of the players reported that they had searched the field systematically, starting search at one end of the field and then using regular right to left or left to right sweeps until the entire field was covered. Their search records, however, indicated that they had not followed this procedure.

In earlier BESRL research at Fort Benning, Georgia, in a similar situation, about 60 minutes of training was given, less time being allowed for familiarization with target appearance and for practice. For some players this training was found to be inadequate. In the present study, training was more highly structured and more practice time was given. By examining Figures 6 - 9, it can be inferred that further practice would not have improved performance. If learning had not been complete, performance should have improved with increasing use of the device and final performance should have been superior to initial performance. It is possible that additional learning occurred which would have been shown as improvement in performance if a simultaneous decrement in performance produced by fatigue and lowered vigilance had not also been present. However, it is highly unlikely that two such independent factors would exactly cancel each other out to produce the essentially flat lines shown.

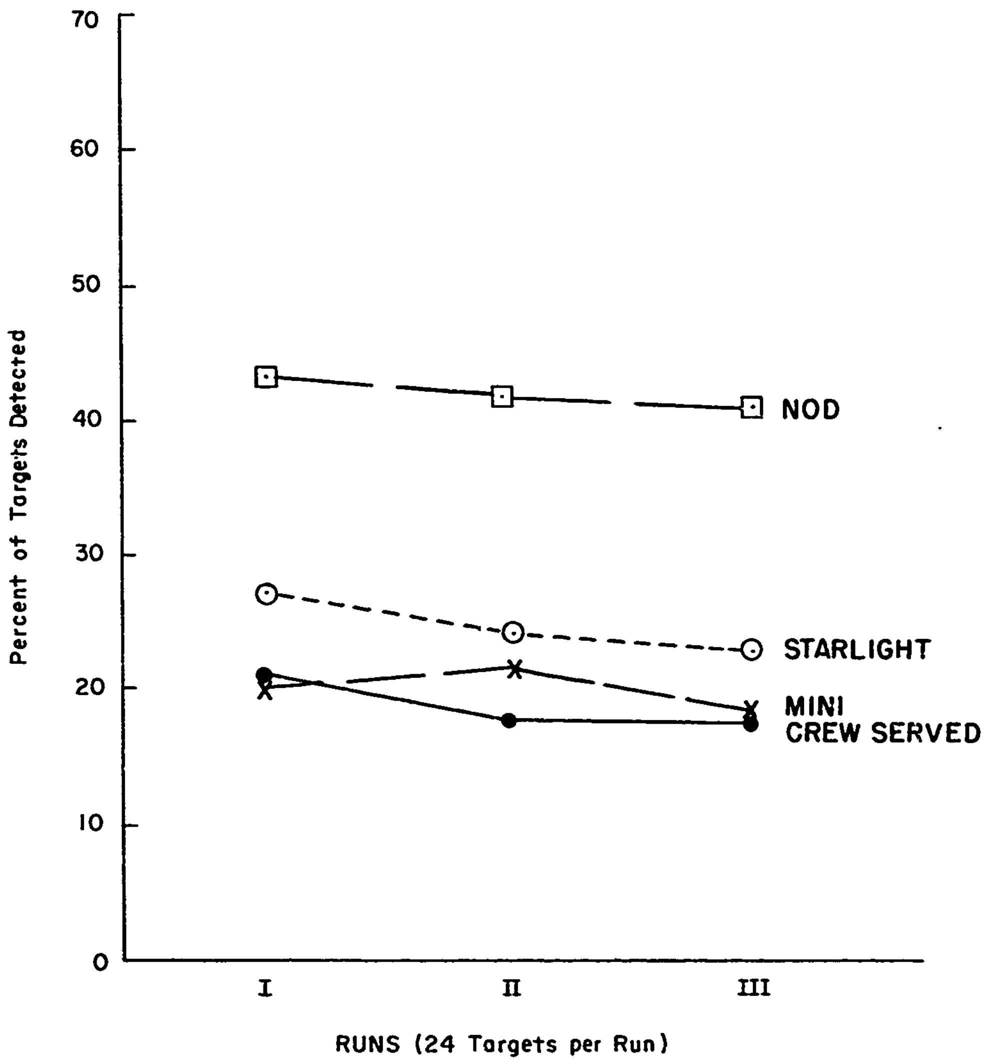

Figure 6. Effects of Prolonged Activity on Percent of Targets Detected under Starlight Condition

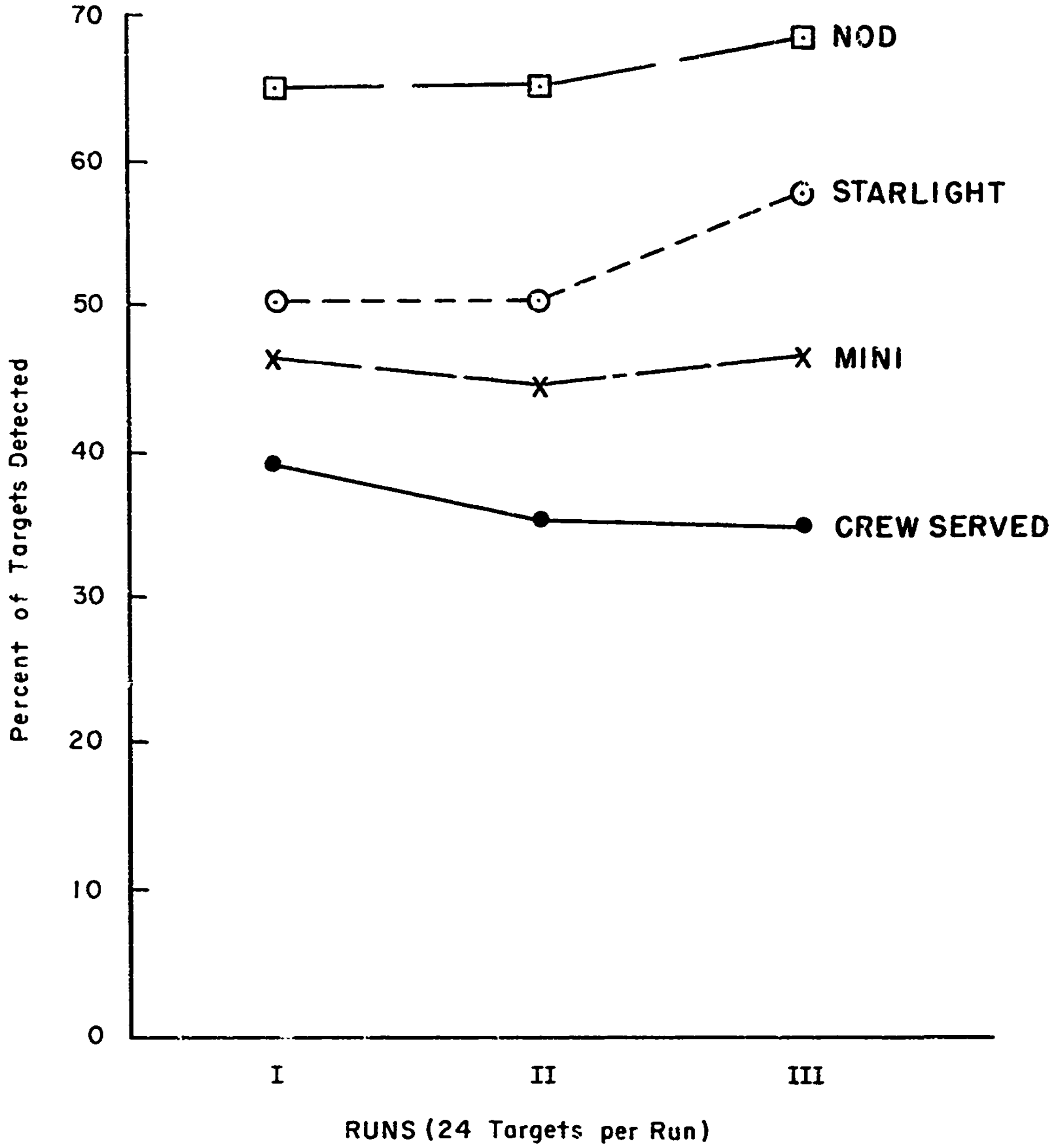

Figure 7. Effects of Prolonged Activity on Percent of Targets Detected under Full-Moon Condition

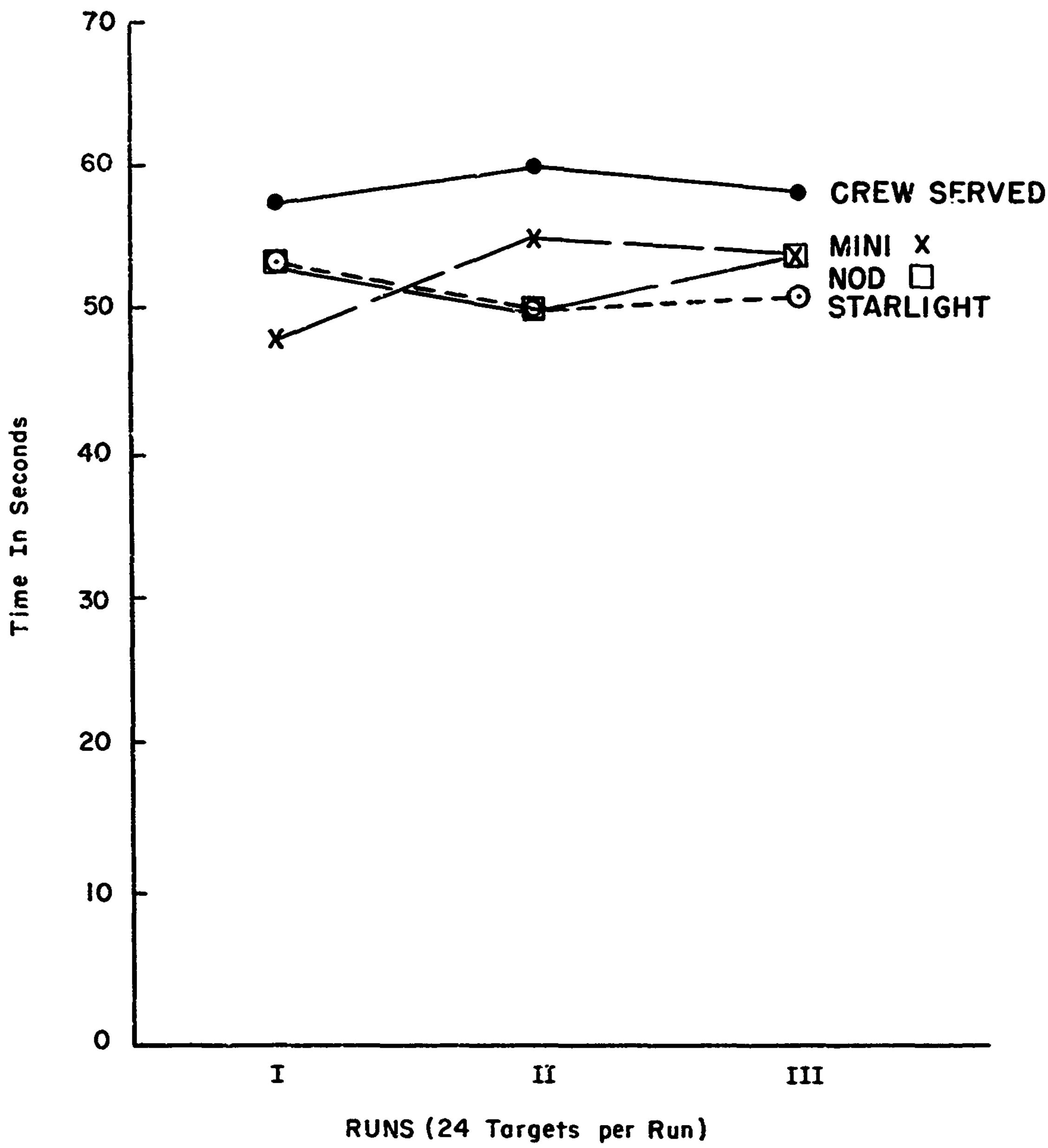

Figure 8. Effects of Prolonged Activity on TARGET DETECTION TIME under Starlight Condition

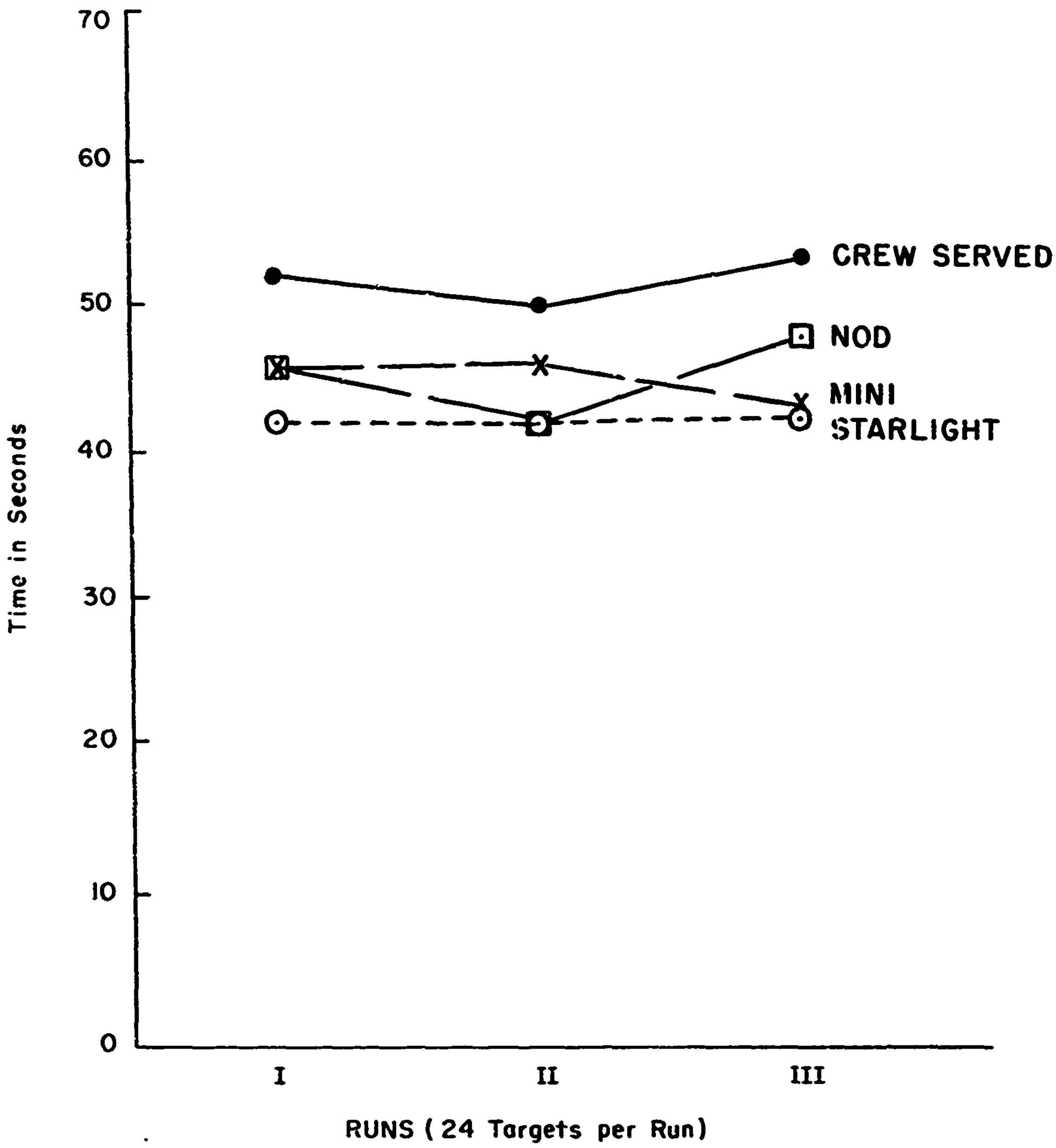

Figure 9. Effects of Prolonged Activity on TARGET DETECTION TIME under Full-Moon Condition

The reader should not infer from these data that additional training would not result in improved performance. On the contrary, additional training probably would improve performance, provided the training was geared to new techniques and new work methods and procedures. Field experiments are now being undertaken to develop new techniques and methods which will lead to improved performance. In the interim, it is worthwhile to emphasize again that the soldiers do not know how to make diopter adjustments and frequently confuse such adjustment with objective lens focus. A simple procedure for diopter adjustment is provided in Appendix A.

Inferences for Basis of Issue and Mix. Increasing the number of men with devices is one highly practical means of improving performance. However, does the degree of improvement justify such action? Is the improvement substantial under all conditions? What combinations of devices are most effective? Answers to these questions have important implications for Basis of Issue (BOI) and Mix. Therefore, the individual performance data were combined statistically to determine the amount of improvement under various conditions with various combinations of devices. The results for percent of targets detected are presented in Table 11 for single and pairs of players. In computing these percentages, a target was considered detected if either or both players, working independently, acquired the target. Thus, if both players in a pair detected a target, the score was not greater than it would be if only one player of the pair detected the target. Under each illumination condition, the diagonal entries in Tables 11 and 12, under "pairs of players", give the percentage detected by two men with devices of the same type. This percentage can be compared with the percentage detected by a single player with a given device. For example, under starlight, the percentage of targets detected with a MINI was 20% by a single player and 31% by a pair, a relative gain of about 50%; for the SS the comparable values were 24% and 38%; for the CSWS, 19% and 33%; for the NOD, 42% and 55%. The non-diagonal entries give the percentages detected by pairs of players with different devices. Under starlight conditions, combinations of the MINI with the SS, CSWS, and NOD detected 34%, 30%, and 47% of the targets, respectively.

From inspection of Table 11 several points are clear. First, substantial improvement results from the use of pairs of men with devices. (As a very rough approximation, the gain under the conditions of this experiment was about 50%.) Second, the gain was relatively greater under starlight than under full-moon conditions. Third, any combination with a NOD was better than any combination not including a NOD, two NODs being the best possible combination. Fourth, there were no marked differences among any combinations of MINI, SS, and CSWS.

Table 12 shows comparable data on target detection time. As suggested by detection time for the single operator, time required to detect targets by pairs of operators was more affected by illumination condition than by combination of devices.

Table 11

PERCENT OF TARGETS DETECTED--SINGLE VS PAIRS OF PLAYERS

Ambient Light Level	Device	Single Player	Pairs of Players MINI	SS	CSWS	NOD
	MINI	20	31	34	30	47
	SS	24	34	38	35	50
STARLIGHT	CSWS	19	30	35	33	49
	NOD	42	47	50	49	55
	MINI	30	51	48	46	57
	SS	36	48	51	48	58
HALF MOON	CSWS	29	46	48	46	56
	NOD	46	57	58	56	66
	MINI	45	63	67	59	71
	SS	52	67	67	63	76
FULL MOON	CSWS	36	59	63	55	71
	NOD	65	71	76	71	80

Table 12

AVERAGE TARGET DETECTION TIME--SINGLE VS PAIRS OF PLAYERS
(In Seconds)

Ambient Light Level	Device	Single Player	MINI	SS	CSWS	NOD
	MINI	52	47	49	52	47
	SS	51	49	48	51	47
STARLIGHT	CSWS	58	52	51	57	48
	NOD	52	47	47	48	44
	MINI	51	46	44	48	42
	SS	48	44	43	45	42
HALF MOON	CSWS	54	48	45	49	44
	NOD	47	42	42	44	41
	MINI	45	39	35	41	38
	SS	42	35	34	39	36
FULL MOON	CSWS	52	41	39	46	41
	NOD	45	38	36	41	38

The time required to detect targets was less for pairs of operators than for a single operator, but the difference was not great, reflecting the substantial number of targets detected by only one operator in a pair. Although it is obvious that two men with devices should detect more targets than a single man, the reasons for improved performance are not so obvious. Is it because the second operator was able to see different targets than the first operator, or because a single operator was not efficiently detecting all the targets that he could see? These two possibilities have different implications for improvement of performance. This point is discussed at greater lengths later.

Search Efficiency. Comparison of devices of different types requires the selection and placement of targets so that range or distribution of scores can be obtained for all devices under all light levels. This variation is necessary in order to determine the nature of the differences in performance that exist among different types of devices under the same conditions, as well as the differences in performance of a single device under different conditions. However, some targets under some conditions for some devices can never be detected because they exceed the capabilities of the man-device combination to see the targets.

The percentage detections reported previously in this report was based on total number of targets presented, whether or not all targets could actually be seen. These data are meaningful because the differential ability to see targets with different devices is a function of the intrinsic properties of the devices and, as such, is an important contributor to the effectiveness. However, another type of comparison is also meaningful. If the differences in device capabilities for seeing targets are partialed out, how effective is the operator in finding targets that he can see? Such an analysis has implications for operational employment of the devices, for engineering, and for improvement of search effectiveness. It was necessary, therefore, to develop a measure of how many targets were actually visible to a given operator with a given device on a given night. (That is, it was to be simply whether the operator could see the target, whether or not he found it during search.)

Seeability Index. A subsample of one-third of the targets used in the study was selected for this measure. From this subsample, targets which were not detected by an individual during search were shown a second time with instructions indicating the target location. The operator was then tested to determine whether or not he could see the target. (As different targets were missed by different operators, the entire subsample of targets was presented at the end of the evening's testing.) This measure is called the Seeability Index (SI) and is derived as follows:

$$SI = 100 \left[\frac{\sum_{i=1}^{N} F_i + \sum_{i=1}^{N} S_i - \sum_{i=1}^{N} F_i S_i}{N} \right]$$

where F = Targets found during search

S = Targets seen without search

N = Number of targets.

Division by N and multiplication by 100 simply converts the raw score into a percentage.

Table 13 presents the Seeability Index scores for each device under each illumination condition.

Table 13

PERCENT OF TARGETS WHICH COULD BE SEEN (SEEABILITY INDEX)

		Ambient Light Level	
Device	Starlight	Half Moon	Full Moon
MINI	43	63	80
SS	52	74	88
CSWS	56	82	87
NOD	83	82	91

The percentage of targets that could be seen varied greatly as a function of both device type and ambient illumination. The ability to see targets improved with increasing illumination but to different degrees for the different devices, the improvement being only slight for the NOD (from 83% to 91% for starlight and full moon, respectively), and very substantial for the other devices (43% to 80% for the MINI). The ranking of the devices from high to low in terms of operator ability to see targets was: NOD, CSWS, SS, and MINI. In general, the NOD operators could see far more targets than operators using the other devices, but the differences among the devices were small under full-moon conditions (the percentage of targets seen ranged from 80% to 91%) and much larger under half moon and starlight (the percentages ranged from 63% to 82% and 43% to 83%, respectively).

Efficiency Score. For ease of comparison, the data shown in Table 13 and Table 3 are presented together in Table 14.

Table 14

COMPARISONS OF PERCENT TARGETS WHICH COULD BE SEEN (SEEABILITY INDEX) WITH PERCENT DETECTED DURING SEARCH

	Ambient Light Level					
	Starlight		Half Moon		Full Moon	
Device	SI	Search	SI	Search	SI	Search
MINI	43	20	63	30	80	45
SS	52	24	74	36	88	52
CSWS	56	19	82	29	87	36
NOD	83	42	82	46	91	65

Table 15 shows the Efficiency Score and was calculated by dividing the original search score by the appropriate SI score. This score expresses the percent targets found during search as a function of the percent targets that could be seen.

Table 15

EFFICIENCY SCORE: PERCENT OF TARGETS FOUND DURING SEARCH AS A FUNCTION OF PERCENT OF TARGETS "SEEABLE"

	Ambient Light Level		
Device	Starlight	Half Moon	Full Moon
MINI	47	48	56
SS	46	49	59
CSWS	34	35	41
NOD	51	56	71

On the average, only about half the targets which could be seen were actually found. Theoretically, 100% of these targets could have been detected. Without changing the devices at all, then, performance could be greatly increased. Table 14 shows that, as the amount of light increased, the percentage of targets that could be seen and the percentage of targets detected during search both increased. Table 15 shows that performance efficiency also increased, i.e., a larger proportion of the targets which could be seen were actually found Additionally, there was considerable difference among devices: The MINI and the SS were about equal; the CSWS was consistently lower; and the NOD was consistently higher. Possible explanation for these differences and some operational implications are discussed below under Search Behavior.

Operator Reliability. Since each target was presented twice, it was possible to analyze the data for hit consistency. If the operator hit the target on its first presentation, did he hit the same target when it reappeared for the second time? An analysis of the operator's overall performance in terms of his percent detections on first presentation of the targets compared to his percent detections on second presentation of the same targets showed a very high degree of overall reliability or consistency of performance. For example, if an operator detected 40% of the targets on the first presentation, he tended to detect about 40% of the targets on the second presentation. However, the specific targets that he detected on the first presentation were frequently different from those detected on the second presentation. An analysis of these data showed that about 50% of the targets were common (hit twice) and the remaining 50% were unique (hit once). In discussing BOI and Mix, the question was asked: Why did two operators detect approximately 50% more targets than a single operator? Was it because operators were able to see different targets or was it because each operator was not efficiently detecting all the targets that he could see? It appears that the improvement achieved by using two operators is more a function of the operator's inefficiency and unreliability in detecting specific targets. This conclusion does not negate the usefulness of using pairs of operators, but it does suggest that it would be far more parsimonious to improve the soldier's reliability. How this individual performance may be improved is further analyzed below. Additionally, subsequent planned research will test out several hypotheses leading toward optimized human performance on the devices under study.

Search Behavior. A continuing theme in the present report is the question of why an operator using a night vision device misses targets. Does he miss targets because he can't see them, because of device capabilities and limitations? The Seeability Index established that a large number of targets were missed for this reason, but the Efficiency Score demonstrated that only about half of the targets which could be seen were actually found. Other analyses showed that neither fatigue nor inadequate training accounted for the large number of targets missed. Other contributing factors discussed here include: target exposure time; device characteristics and their relation to the method of employment; search procedures.

Target Exposure Time. Were substantial numbers of targets missed because the targets were not exposed for a sufficient amount of time, considering the terrain difficulty and the size of the search area? Pilot studies conducted prior to the present study indicated that a two-minute target presentation was more than adequate to detect the targets. These initial studies were substantiated in the present study by analysis of time required to detect targets. Only a small percentage of targets were found after 90 seconds (see Table 5). Therefore, missed targets cannot be explained by inadequate target exposure.

Device Characteristics and Methods of Employment. Table 15 shows considerable differences among devices in number of targets found in relation to those seen: the MINI and SS were about equal; the CSWS was consistently lower; and the NOD was consistently higher. Why these differences exist can be explained, in part, by device limitations or advantages. In part, the explanation also lies with the manner in which the devices were employed. A greater proportion of targets could be seen with the CSWS than with either the MINI or SS (Table 13) and yet fewer targets proportionally were found with the CSWS. Why? The field of view of the CSWS is about one-half that of the SS or MINI. Considering that the area to be searched was 75° wide, it is possible that the requirement to search a large area accounted for the relatively poorer performance of the CSWS. In a subsequent experiment, this hypothesis was confirmed. (This finding suggests that when the CSWS is operationally deployed, the search area size should be limited. This limitation could present a tactical complication if it is desirable to mount the CSWS on a machine-gun positioned to cover a wide area.) But the NOD also has a limited device field of view compared to the SS, and yet performance with the NOD was consistently better. The NOD, however, has other properties (such as greater light intensification and better resolution) which more than compensated for limitation of field of view.

In spite of differences among devices in the number of targets found compared to those seen, performance on <u>all</u> devices suffered severely in terms of missed targets. The most likely contributor to failure in target detection was assumed to be in the operator's search behavior--his search techniques, work methods, and procedures--or in his training. These possibilities will be further studied in subsequent experiments. In order to develop hypotheses for these planned studies, as well as provide some information at this time, data on search behavior of players in the present study were analyzed in several ways.

Search Procedures. Subjects were allowed to use any search technique that they preferred. They were, however, encouraged to search the entire field and to stay in a continuous search mode.

After finding a target, they were to continue searching until told to stop. The experimenters had a high degree of assurance that this procedure was being followed, based on electronic monitoring at the Experimental Control Center and assignment of an instructor to each player. In spite of these instructions and procedures, half the targets that could be seen were not detected. Additionally, considering only the targets detected, operators were highly unreliable in their detection of specific targets. One possible explanation for these findings is that the player simply did not look where the target was. Therefore, the data were analyzed to determine what percentage of targets missed were never captured in the device field of view. The results are startling. (Table 16)

Table 16

PERCENTAGE OF MISSED TARGETS WHICH WERE NEVER IN THE DEVICE FIELD OF VIEW

	Ambient Light Level		
DEVICE	STARLIGHT	HALF MOON	FULL MOON
MINI	28	22	18
SS	25	20	10
CSWS	46	41	38
NOD	25	25	24

The percentages in Table 16 are based only upon targets missed, not upon the total number of targets presented. Thus, under starlight conditions, the <u>relative</u> performances of the MINI (28%) and the NOD (25%) are the same on this measure although the actual <u>number</u> of targets missed is different for the two devices. From inspection of this table, several points are clear. First, with the MINI, the Starlight Scope, and the NOD, the player never had the opportunity to detect approximately 25% of the targets missed because they never directed their devices toward the target when it was exposed. Second, with the CSWS, 46% of the targets were missed for the same reason and performance of the players with the CSWS was much inferior to that of the players with the other devices. The CSWS, therefore, appears to be relatively ineffective for searching a large area. Third, with all devices except the NOD, the percentages decreased with increasing illumination, suggesting that search was more comprehensive under the higher light levels. Fourth, with all devices, substantial numbers of targets were missed because of lack of adequate coverage of the search area.

These results explain why a sizable percentage of the targets were missed, but still leave much of the variance unaccounted for. For example, with the SS under starlight conditions, 25% of the missed targets were never in the device field of view. Explanation is still required for the remaining 75% of the targets that were missed. Another obvious reason for missing targets is that the targets were in the device field of view for a very limited time, i.e., the operator was scanning too rapidly and failed to observe the target even though it was somewhere within the device field of view. How much time with the target in device field of view is needed for detection? As a first step toward an answer, it was necessary to determine for each device under each ambient condition how long the player had the target in the device field of view when he made a detection. A frequency distribution was constructed, based on hits only, for the number of seconds the target was within the device field of view prior to being hit. These data were obtained in the following way: As the operator was searching the field, the target at some time "entered" the field of view of his device. Entrance could occur a number of times prior to the operator's detection of the target if, indeed, he was going to detect the target at all. On the occasion that the operator was going to shoot the target, the moment of entry of the target in the device field of view was "zero time". The moment the operator actually pressed the response button (i.e., "shot" the target) was "hit time". The difference between "zero time" and "hit time" was measured in seconds, and the number of targets hit after one second in the device field of view was determined. Similarly, the number of targets hit at two seconds, three seconds, etc., was determined. The number of targets hit in each class interval was then divided by the total number of targets detected to obtain the percentage of targets in each interval. The resulting frequency distribution revealed that, under starlight conditions, four to ten seconds, depending on device type, were required for detection of 33% of the targets that were going to be detected, and that eight to fourteen seconds were required to reach the 50% level. Under full-moon conditions, five to seven seconds and seven to nine seconds were required to reach the 33% and 50% levels, respectively.

Thus, in general, even considering only targets which were ultimately detected, the probability was low of detecting targets which were in the device field of view for less than five or six seconds. Six seconds was therefore established as criterion time for analysis of missed targets.

Time in device field of view was determined for targets which were missed, and a frequency distribution was prepared, excluding those targets which were never in the device field of view. These data were obtained in a way similar to those for targets detected, except that total time in field of view was used--the accumulated time of one or more occasions when the target "entered" the device field of view.

Thus, these times are not strictly comparable to times for detected targets, which were based on a single occasion (the occasion when the target was detected) but are to some degree a comparative over-estimate of the time in device field of view on a single occasion.

The frequency distribution resulting from this analysis was then examined to determine the percent of occasions that the missed target was in the device field of view for six seconds or less. Under starlight conditions, with the MINI and the SS, approximately 40% of the missed targets which had been in the device field of view were in the field of view for six seconds or less. With the CSWS and the NOD, comparable values were about 70% and 50%, respectively. Under full moon, the values were essentially identical. Thus, with all devices, a considerable number of the targets which were in the field of view, but missed, were in the field of view for too short a time to have a good probability of detection.

The first analysis indicated that the target frequently was <u>never</u> in the device field of view, suggesting that the operators were not making a comprehensive search of the area. The second analysis indicated that the instrument scanning was frequently too rapid to give a high probability of detection.[5] Improved search procedures could reduce the number of targets missed for these reasons and thus substantially improve overall effectiveness. To summarize the findings of this section, operators can use night vision devices for prolonged periods of time, probably an entire night, without their performance being degraded. The training given in the present study was adequate in that no improvement of performance occurred with increasing use of device. This finding does <u>not</u> imply that additional training geared to new techniques and work methods and procedures would not improve performance. Performance is considerably improved by the use of pairs of men with devices. Any combinations of MINI, SS, and CSWS are about equally effective, but any combination including a NOD yields better performance. Device operators are not efficient in detecting targets that are within the man-device capabilities. A substantial proportion of the targets which were not detected were never in the field of view of the device, indicating that search procedures used by the untrained operators do not produce a comprehensive coverage of the search area. An additional proportion of the targets which were not detected were in the device field of view for a relatively short period of time. Improved search procedures should therefore substantially improve overall system effectiveness.

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[5] In a subsequent experiment, search area sizes of both 75° and 25° were employed, using the same terrain and targets as in the present study. This experiment provides data on the relationship between time of target in the device field of view and search area size. The report of this experiment is in preparation.

Field Research Technology

A second purpose of the experimentation was to develop a technology which would make it possible to collect reliable and valid experimental data under field conditions. This technology consisted of three major components: instrumentation, procedures, and new experimental techniques.

Instrumentation. Universal device platforms (UDPs) were developed which would accept any of the passive night vision devices and, with minor modification in adaptors, other types of devices as well. The UDPs give maximum flexibility to the system and permit variation in number and type of devices. Each UDP contains instrumentation which permits the determination of orientation (both azimuth and elevation) of a device with a 0.1^{o} accuracy. It also contains multiple response buttons for recording up to six responses from a player. The UDPs thus permit the determination of target acquisition with a much higher degree of accuracy than would be possible with any non-instrumented system.

Output from the UDPs is fed into a data recording system which records device orientation and all player responses on magnetic tape. In the experiment reported here, device orientation was sampled five times per second, thus providing a complete and fine-grained record of the search procedure used by all players. The recording of data on magnetic tape permits immediate computer analysis, without the hand preparation otherwise required, thus reducing data analysis time. The tapes also constitute an extensive library of search performance records and permit detailed analyses of search behavior.

The system also permits continuous monitoring of player performance by providing real-time visual displays of player search behavior and target acquisition responses, as well as a graphic hard-copy record of search and target acquisition. This monitoring capability was found to be essential. During training, it resulted in quick identification of players who needed additional instruction, thus reducing training time and assuring adequate training for all players. During testing, it made it possible to identify players who were not cooperating or not following correct procedures, thus enhancing player control and the resultant reliability and validity of the data.

The system showed a high degree of reliability, with a minimum of down time. This reliability was increased by aspects of the system which permitted checks to be conducted on system operation both before and during a run, thus enhancing not only system reliability but also the reliability and validity of the data collected. The use of magnetic tape recording made it possible to get a computer output immediately after each night's run. From this, quick identification and location of any system malfunction could be made, and rapid correction of the malfunction could prevent the accumulation of inadequate data, with a resulting savings of military resources.

Procedures. The large number of men required for field research, including player, support, and controller personnel, introduces a huge source of error. An effort, largely successful, was made to demonstrate to all personnel the importance of their role and to increase their involvement in the study in order to motivate them to perform at a high level. Great attention was also paid to the training, cross-training, and retention of support and controller personnel. In addition, however, it was necessary to develop highly specific, detailed, and redundant procedures, emphasizing checks and cross-checks of all aspects of the experiment, in order to assure standardized test conditions.

Players. During both training and testing, players were individually monitored on two levels, by instrumentation and by direct observation. During training, players were monitored on the instrumentation to insure that they understood and were following correct procedures. Players having difficulty were given additional instruction and help. During testing they were monitored to insure that they were searching in the prescribed area, searching continuously and at a reasonable rate, and that they were shooting at the targets in accordance with the instructions. Each player was also directly monitored by an individual instructor. It was found that it was also necessary to have one man monitor and control the instructors to insure that they were following correct procedures and to assist them in the control of the players. Through these procedures, it was possible to identify players who were not following instructions--for correction or exclusion, if necessary, from the test or subsequent data analyses--thus reducing the error variance attributable to the players and increasing the reliability and validity of the data.

Targets. Target personnel were controlled in three ways: 1) repeated alerting prior to target presentation; 2) strict reporting procedures; and 3) a target monitor on the test line who directly observed and confirmed target behavior and reports. As a result of these procedures, on a typical night, 71 of 72 targets appeared in the proper location and on schedule.

Controllers. To facilitate the work of the controllers, simply worded, highly specific, and sequential checklists, schedules, and routines were developed. Each controller was cross-trained in another controller's job and had the secondary job of monitoring the performance of the other controller. These procedures greatly reduced the number of errors. Equally important, the procedures made it possible to identify an error when it did occur so that the error could be corrected or controlled for in subsequent data analysis, thus improving data reliability and validity.

Experimental Techniques. Experimental techniques were developed for two purposes: to make it possible to partial out and determine the effects of various factors on performance and to prevent players from learning the schedule or type of targets being presented. The determination of how effectively the operator's were using the devices was an important element of the study as this would indicate the amount of improvement possible and suggest techniques for improving performance. The different device types varied greatly in their intrinsic capabilities. Thus, target difficulty varied with device type and a simple measure of percent detection was not adequate, as this measure confounded device and operator factors. The usual correlates of target difficulty--measures of illumination, distance, etc.--did not differentiate among devices and did not make it possible to differentiate device and operator factors. An experimental technique was needed which would make it possible to partial out the relative contributions of device and operator factors to performance. The Seeability Index was developed to determine what proportion of targets could actually be seen on a given night, by a given operator, with a given device. This measure revealed considerable differences among devices and among operators in ability to see targets, as well as the differences due to other factors such as illumination. The Efficiency Score, considering only targets that an operator could see, showing how efficiently he found these targets during search. As reported previously, on this measure the large initial differences among devices disappeared. With all devices, only about half the targets that could be seen were actually found, indicating a large area of possible improvement.

In order to encourage continuous search, players were instructed that no targets, one target, or several targets might be visible in the field at any given time. To prevent the players from learning that only one scorable target was, in fact, presented at a time, a second target--a dummy--was presented periodically but not scored. As engine noise directed the attention of the players to the location of vehicular targets, extraneous engine noise was periodically introduced to reduce the value of engine noise as a cue. In debriefing the players, it was found that they had not known how many targets were in the field at any time and that target engine noise had not been a usable cue.

APPENDIXES

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APPENDIX A BRIEFINGS AND INSTRUCTIONS TO PERSONNEL PARTICIPATING IN EXPERIMENTATION ON SEARCH EFFECTIVENESS WITH NIGHT VISION DEVICES

MILITARY BRIEFING

Tonight you are going to participate in a military experiment conducted by the Behavior and Systems Research Laboratory of Washington, D. C. This experiment is being run in order to find ways to improve the American soldier's ability to fight at night. In this experiment, you will be given some tests and questionnaires and then you will be using night vision devices for several hours.

The Army is very concerned with improving our capabilities to fight at night. Many of you have been in Vietnam, so you are well aware of the importance of this. One way of improving this capability is with the use of night vision devices. We have the devices but the Army needs to know the best way to use them and how to improve them. We are conducting these tests to get some of the information.

We need your cooperation and assistance tonight in order to get this information. You are going to be out here for several hours; you may get tired or even bored. At various times, you will have an opportunity to take a break, smoke, and get some chow. Even though you get tired, please remember that what you are doing is important and that what you do tonight may help prevent someone from being killed in Vietnam or in future conflicts.

At this time, I will introduce the civilian scientist who will give you more of an idea of what you will be doing during the experiment.

APPENDIX A BRIEFINGS AND INSTRUCTIONS TO PERSONNEL PARTICIPATING IN EXPERIMENTATION ON SEARCH EFFECTIVENESS WITH NIGHT VISION DEVICES

MILITARY BRIEFING

Tonight you are going to participate in a military experiment conducted by the Behavior and Systems Research Laboratory of Washington, D. C. This experiment is being run in order to find ways to improve the American soldier's ability to fight at night. In this experiment, you will be given some tests and questionnaires and then you will be using night vision devices for several hours.

The Army is very concerned with improving our capabilities to fight at night. Many of you have been in Vietnam, so you are well aware of the importance of this. One way of improving this capability is with the use of night vision devices. We have the devices but the Army needs to know the best way to use them and how to improve them. We are conducting these tests to get some of the information.

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At this time, I will introduce the civilian scientist who will give you more of an idea of what you will be doing during the experiment.

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APPENDIX A

CIVILIAN BRIEFING

The experiment that we are running is important to the Army and will provide information on how to improve our capabilities for fighting during the night. Your cooperation is absolutely essential if we are to get this information. Basically, we are trying to find out the best way to use these devices.

Here is the situation. You are on perimeter defense. You will be given a night vision device and assigned an area to cover. Your job is to find the enemy and to shoot him. The shooting, of course, is simulated. The enemy will consist of soldiers, tanks, APCs, trucks and jeeps.

As you go through the experiment, you will be given detailed instructions before each phase, but right now I will give you a general idea of what to expect. First, you will be given a couple of tests. When we compare the test results with your performance with the devices, we expect to find relationships that will give us some information on how to select and train operators. Testing will take a little over an hour. Next, you will receive about 90 minutes of training on how to use the devices and how to shoot targets. After training, you will use the devices for several hours to search for and shoot targets. This time will be broken up into several search periods. Each period will be about 30 minutes long. You will have a break between each search period. When you are using your device during the training and search sessions, all of your responses will be automatically recorded. That is, every second of the time that you are using a device, we will have a complete electronic record of where you are pointing your device as well as any responses that you make. In a few minutes, we will take you over to the experimental control center so that you can see what this system looks like, but do you have any questions at this time?

O.K. Before we move out, let me stress a few points. First, the work that all of us are doing here is a serious business, and the results are of critical importance to the soldiers who will be doing the fighting. Research of this kind takes a lot of money and a lot of people. We have the most sophisticated equipment that money can buy, and we have picked a lot of brains to figure out how to best use it ... but, in the final analysis, none of it is worth anything if we can't get the support and cooperation of the players such as you. All of the people you see around here, all of the equipment, and all of the vehicles are here to support you ... to determine how effectively you use these devices ... so you are the most important people out here. If you fail to perform to the best of your ability, we have wasted a lot of time, a lot of money, and a lot of hard work. That's the reason we need your cooperation and help.

Are there any questions? If not, the sergeant will take you over to the control center and we will show you what goes on there.

APPENDIX A

INSTRUMENTATION BRIEFING

Gentlemen, this is our automatic data recording system. The system tells us precisely what you are doing with your devices at all times. Here is how it works.

Each device mounted in the booths on the line is instrumented so that we know the azimuth and elevation of each device to the nearest 1/10°. There are also response (firing) buttons with each device. The device azimuth, elevation, and firing button information is then fed into the console. The system looks at each booth five times every second, and puts the azimuth, elevation, firing button, and target identification number on the magnetic tape. The computer knows precisely where each target is located and when it appears. The computer then compares what you are doing with where the targets are located in order to score your performance. The system gives us a complete record of every movement you make with your devices. This gives the most complete library of search performance in the world.

We also have these NIXIE tubes to monitor your performance during the course of the runs. We scan each booth by depressing the booth number here, and reading your azimuth and elevation on the NIXIE tubes. If you have depressed your firing button, one of these lights will light up. We have a man in Booth 4 now. You can see here how he is moving his device and when he fires. In addition to the magnetic tape record, the NIXIE tubes, and the response lights, we have this stripchart recorder. The recorder draws a graph of your device movement and shows us a picture of how you are searching. It also shows when a target is exposed and where the target is located, as well as when you fire at a target.

We use this system to constantly monitor your performance to make sure you are actually searching and are following the correct procedures. We also use it to do a complete analysis of how people search with the various devices.

Are there any questions? If there are no (further) questions, please move out of the control center. Your individual instructors will pick you up outside the control center door and escort you to the briefing building.

APPENDIX A

TRAINING INSTRUCTIONS

PART 1

Before we begin the exercise tonight, we will go through a training session. This session will take about 90 minutes. Following this session you will be given a break. In this session we are going to do three things:

1. Acquaint you with your device.

2. Show you what targets look like through the device.

3. Give you some practice with the device so you can develop some skill in rapidly finding and shooting the targets.

Tonight each of you will be using one of these devices. This device (point) is a Miniscope. This device (point) is a Starlight Scope. This device (point) is a Crew Served Weapon Sight. This device (point) is a Night Observation Device, or NOD.

These devices all work in the same way. They take whatever light is available and electronically intensify or increase it so that you can see things through the device that you cannot see with your naked eye. You do not need any artifical light source, like an infra-red searchlight, to be able to use these devices.

Each of these devices has an on/off switch. Your instructor will turn the device on and off when necessary. You should not touch the on/off switch during the experiment.

After the device has been turned on, you must press your eye against the rubber eyepiece before you can see through the device. This takes just a little pressure (demonstrate).

There are only two basic controls that you need be concerned with tonight. These are for:

1. Focusing your device.

2. Diopter or eyepiece adjustment.

First, I will show you the focus adjustment. You focus in order to make sharper the image that you see through the device. If the device is not focused properly, the "picture" you see through the device will be fuzzy. If any of you have worked with cameras, you know that you must adjust the focus for the distance of the object that you are taking a picture of. If the object is too close it will be fuzzy; if it is too far away it will be fuzzy. You adjust the focus so as to make your picture sharp. Each of these devices has a focus adjustment. I will demonstrate.

On the Miniscope, focus is adjusted by turning this ring. On the Starlight Scope, you must rotate this ring around the front of the scope. On the Crew Served Weapon Sight, focus is adjusted by this lever. On the NOD, you use this wheel with four spokes. This focus ring on the Starlight Scope is hard to turn and it is hard to change the focus rapidly. We have found in the past that when players adjust the focus they are likely to get the focus badly out of adjustment. We have adjusted the focus on the Starlight Scope so that all the targets are pretty sharp. Those of you with the Starlight Scope, therefore, will not adjust the focus during the experiment. Those of you with the other devices can adjust the focus as you see fit. A little later, you will have a chance to use the devices and get a feel for how to adjust the focus.

Next, I am going to tell you about the eyepiece adjustment. The purpose of this adjustment is to adjust the device to your own particular eye. To make this adjustment properly, you must follow a strict procedure which I will describe in a minute. First, though, I want to emphasize a few points. First, this adjustment has nothing to do with the focus of the device. It only adjusts the device to your eye. Once it is properly adjusted, you should not touch it again. We will record the adjustment for each of you. If you accidentally move it, tell your instructor and he will reset it. Second, it is extremely important that you make this adjustment properly. If you set it incorrectly, your eye has to adjust to the device rather than adjusting the device to your eye. As a result, you will get more tired and you won't use the device as effectively. Third, for most of you who wear glasses, this adjustment will do the same thing for your eye as your glasses do, so do not wear your glasses.

All right, now I will describe the procedures to you. Please listen carefully. When you get out on the line, your instructor will give you instructions again and walk you through the procedure. Adjustment is made by rotating this ring. The numbers on this ring go from +4 to -4. The first step is to turn the ring all the way to +4. The instructor will do this first step for you. Next, you put your eye to the eyepiece and aim the device at the sky. Grasp the adjustment ring and very slowly--I repeat, very slowly--turn it counterclockwise. You should see a T-shaped reticle in the center. If you do not see it, continue turning very, very slowly. Continue turning slowly until the T-shaped reticle becomes clear. Now, turn the ring a little more and, if the reticle is as sharp as it was before, continue turning. When the reticle starts to become less sharp or when it doesn't seem as comfortable, STOP, and turn the adjustment ring back just a very small amount. The device is now adjusted for your eye and does not need to be adjusted again. Let me emphasize, this does not focus your device. It simply adjusts the device to your eye. Once the adjustment is made, you should not touch this adjustment ring again.

Are there any questions?

All right. You should now move outside the building where you will be assigned to a booth, and we will continue training on the line.

(Instructions read by test director to all players, over booth intercom.) All right. We are ready to continue with training. In the booth with each of you is the device you will be using for the rest of the evening. Your instructor will now help you to adjust your device and show you how to use it. Instructors, please take over now and report when you are ready to continue. (Wait for report from instructors before beginning PART 2.)

(Instructions read by individual instructor to player with NOD. Similar instructions were read to players with other devices.)

The device that you are using tonight is called the Night Observation Device or NOD. This switch turns the device on. I will turn it on and off when necessary. You should not touch this switch during the experiment.

The device is activated by pressing your eye against the eyepiece. Your device has been focused for about 500 meters. You may change the focus with this wheel with the four spokes during the course of the evening.

Now, we will adjust the lens to meet the specific needs of your eye. Listen carefully as I read the next paragraph to you. I will read it twice and during the second time you will make the necessary adjustments.

(Instructor sets diopter at +4 or all the way clockwise.) Press your eye to the eyepiece. Aim your instrument at the sky. Grasp the adjustment ring and very slowly, I repeat, very slowly, turn it counterclockwise. You should see a T-shaped reticle. If you do not see it, continue turning very, very slowly. Continue turning slowly until the reticle becomes clear. Now turn the ring a little more and if the reticle is still as sharp as it was before, continue turning. When the reticle starts to become less sharp or when it doesn't seem as comfortable, STOP, and turn the adjustment back just a very small amount. You may go back only once, so be sure that you proceed slowly and carefully. Once you get the setting, do not touch this adjustment again this evening. You may, however, change your focus with the four-spoke wheel if you wish, but you are not to touch the eyepiece adjustment again this evening.

I will now read the instructions again and as I read them you will make the adjustment. (Reread instructions.)

I will now show you the limits of your search area. Your azimuth is limited by stops placed in your device. Do not try to force the device to go beyond these limits. Your search for distance should not exceed 1500 meters. (Instructor shows player the range of the field.)

This is the way you shoot a target. You press this button gently without moving your scope. Please press this button now, several times.

O.K. Stand easy until we are ready to proceed. (Instructor reports that instructions and adjustments are completed.)

PART 2

(Instructions read to all players over booth intercom.) Very good. We are ready to continue. Now here is the situation. You are on perimeter defense. In the search area indicated by your instructor, there will be from time to time enemy targets. These targets will be one or more enemy soldiers and vehicles consisting of $\frac{1}{4}$-ton trucks, $2\frac{1}{2}$-ton trucks, APCs, and tanks. Some of these targets will be stationary and others will be moving. Your job is to find them as quickly as possible and shoot them. Search for them in the best way that you know how. You will be scored electronically by the number of targets that you find and the speed with which you find them. Some of these targets will be very difficult to locate. Do not get discouraged, just continue to search.

Remember, the targets you are searching for are either vehicles or human targets. The human targets may be single men or small groups. Consider a group of soldiers close together as one target. When you detect something that may be a target, line up the center of the reticle with the center of the target, just as if you were aiming a rifle, and gently press the firing button on your instrument. Do this as rapidly as you can, but be careful that you do not move the reticle off the target. This is how you <u>shoot</u> the target, so aim and fire carefully. Our equipment will tell us whether you have hit or missed the target. It is very important that you understand and follow this procedure. When you have found a target, rapidly line up the sights with the center of the target and press the firing button. <u>Always remove your finger from the button after you have pressed it</u>. Sometimes you will shoot a possible target and then decide that it was not a <u>real</u> target. If so, simply continue searching the field until you detect another target and continue with the regular procedure.

For this part of the training session, we will help you in locating and identifying the targets. The procedure will be as follows:

- One target will be presented at a time.
- You will be told when that target appears.
- The target will have a light on himself or his vehicle.
- The instructors will help you locate the target.

Now here is what we want you to do:

- You are to line up the reticle on the light and press your firing button.
- Do not move your scope after you have fired. I repeat, do not move your scope after you have pressed the firing button--simply stay on the light.

- When all the players have found the target and shot it, the light will go off, but the target will remain exactly where it was for another 60 seconds.

- After the light goes out, if you can see the target, shoot it again. If you do not see the target, do not shoot, but continue looking for it.

- If you can see the target, we want you to study it so that you will become familiar with how the targets appear in your scope.

- If you do not see the target, do not get discouraged since some of these targets are very difficult to see with some of the devices.

- Are there any questions?

- Stand easy. We will begin in a few moments.

(Test director waits for report that first target is in position.)

O.K. We are ready to begin.

(First Target). About 100 meters to your front is a human target. He is stationary and has a light on himself. When I tell you to start, you are to grasp your device, find the target, line up the reticle with the target, and press the firing button. Please remember not to move your scope after firing. Then when the light goes off, if you see the target, fire again, and study the target for the remaining 60 seconds. Get ready to start, (pause) O.K. START! (Wait one minute after all players have shot target and light is extinguished.) STOP! TURN AROUND.

O.K. Very good. We will repeat the procedure with the same target, but this time he will be moving. All right. START! (One minute after light is extinguished.) STOP! TURN AROUND.

(Third Target). This time the target is a ¼-ton truck and is located about 400 meters to your front. Use the same procedures. Ready, START! (Wait one minute after light is extinguished.) STOP! TURN AROUND.

(Fourth Target). This time the human target is to your left and about 500 meters away. Use the same procedure. When I tell you to start, find the target, squeeze the firing button gently, and shoot the target. Get ready. START! (Wait one minute after light is extinguished.) STOP!, AND TURN AROUND.

(Fifth Target). This time the target is a moving M-60 tank about 900 meters to your right. Again, using the same procedures, START! (Wait one minute after light is extinguished.) STOP!, AND TURN AROUND.

Very good. For the next group of targets, we will be using a similar procedure, but we will not tell you where the target is located. At first, the target will be lighted, but you will have to find him. If you cannot find the lighted target, after 30 seconds your instructor will assist you in finding the target. Remember, shoot the target as soon as you see the light, hold your device steady until the light goes off, and then shoot the target again if you can see it. We will tell you when a new target is presented.

(Sixth Target). Get ready. START!

(Seventh Target). A new target is up.

(Eighth Target). A new target is up.

(Ninth Target). A new target is up.

(Tenth Target). A new target is up.

(Eleventh Target). A new target is up.

(Twelfth Target). A new target is up.

(Thirteenth Target). A new target is up.

(After Target 13 is completed) STOP! TURN AWAY FROM THE FIELD.

PART 3

Very good, men. Now we are ready to continue with the training session. The procedure that you will now use is the same procedure that you will use later on. There will not be any more lights to assist you.

Remember, at any one time there may be no targets, one single target, one group target, or several targets in your search area, so when you have shot one target begin searching for other targets. You may sometimes not be sure whether or not you have shot a particular target before. If so, shoot him again using the same procedure previously described. A group target need only be shot once. You need not single out each individual man in a group. Just shoot the entire group once.

When you are in place by your instrument, you will be told to get ready and when to start. When you start, grasp the instrument lightly, put your eye to the eyepiece, and begin searching. Do not touch or look through the instrument until you are told to do so.

Do not stop searching until you are told to stop; then immediately take your eye away from the instrument and turn away from the search area. You will search for about 30 minutes and then you will move to the tent for a break.

If you feel that your instrument is not working properly, inform your instructor.

Let me repeat the points you are to remember during practice and during the rest of the exercise.

1. You are responsible for detecting enemy activity only with the area previously indicated. Do not search outside this area.

2. The targets you are searching for are enemy soldiers and vehicles.

3. When you are told to start, grasp the instrument lightly, put your eye to the eyepiece, and immediately begin searching.

4. As soon as you detect a target, lay the reticle on the center of the target, press the firing button carefully making sure that you do not move the scope as you fire. Do not hold your finger on the firing button.

5. Once you have pinpointed and shot a target, continue searching for other targets.

6. When I say "STOP", immediately take your eye from the eyepiece and turn around and face away from the field.

7. When you are actually searching the field, <u>do not smoke or talk.</u>

8. If you feel that your instrument is not operating properly, inform your instructor.

It is very important that you understand and follow these instructions. You will now have an opportunity to ask questions about anything that you do not understand. Are there any questions before we continue practice? If so, ask your instructors. Will the instructors please inform this station if there are any questions.

(Wait)

We are now ready to resume training. All right. START SEARCHING.

(Upon completion of 12 targets) STOP! TURN AWAY FROM THE FIELD. Instructors, take your players into the rest tent.

APPENDIX A

SEARCH TEST INSTRUCTIONS

We are now ready to continue with the exercise. Upon completion of these instructions, you will take your assigned position by an instrument. Remember, you are searching for enemy soldiers and vehicles. At any time there may be no targets, one target, or several targets in the field. The targets that are present may be moving or stationary.

Your search area extends out to about 1500 meters. In azimuth, it is limited by mechanical stops. DO NOT FORCE THE DEVICE TO SWING PAST THE MECHANICAL STOPS. Search only in the search area.

When I say "READY," prepare to use your instrument. When you hear the command "START," grasp the instrument, put your eye to the eyepiece, and begin searching. Do not touch or look through the instrument until you hear the word, "START". When you detect a target, immediately place the center of the reticle on the center of the target, and press the firing button. Do this as rapidly as you can, but be careful that you do not move the sights off the target. After you have pressed the button, remember to always remove your finger. There may be times when you are not sure whether or not you have shot a particular target. If so, shoot him again, using the same procedures previously described.

During this phase of the exercise, you will search the area for targets for approximately 30 minutes. Remember that at any one time there may be no targets, one target, or several targets in the field, and it is never safe for you to assume that you have found all the targets. The targets will be either human beings or vehicles. Your job is to find and shoot all the targets.

When you are told to stop, immediately release the instrument and turn away from the field. You will be given breaks periodically, at which time you may smoke and talk and rest in the tent.

If at any time you feel that your instrument is not working properly, ask your instructor for assistance.

READY --- START!

APPENDIX A

SEEABILITY TEST INSTRUCTIONS

Now we are going to try something different. What we want to find out is whether you can see a target and then tell us when it disappears.

Here is how we will do this. A target will appear with a light on himself or his vehicle. Your instructor will assist you in finding the target. When you find the target, lay the reticle on the center of the target and press your button. Do not hold your finger on the button. And most important, do not move your scope after you have found the target and fired at it.

When all of the players have fired at the light, it will go off. Stay on the target or where it was until it starts going into defilade. When it starts to move or disappears, fire immediately. Targets will be up for different amounts of time, so don't expect them to stay up for the same period. One caution: When the light goes off, you may lose the target temporarily due to a light smear on your device. No target will disappear within 5 seconds, nor will it move. When a target run is over, an instructor will instruct you to stop and then when to start again. O.K., let's review:

1. Find light, lay on reticle, and shoot.

2. Do not move scope.

3. When the light goes out, watch the target, if you can see it.

4. As soon as the target starts to move, fire on it. Do not wait. Fire as soon as the target starts to move.

5. If you do not see the target several seconds after the light goes out, you will not be able to see when it moves into defilade. In that case, do not fire at the target.

6. Start and stop at my command.

If there are any questions, ask your instructors now. O.K. Stand easy for a few moments.

We will now begin with one practice target to further acquaint you with the procedure. This target is ready. START!

APPENDIX B EXPERIMENTATION PROCEDURES

INTRODUCTION

The collection of reliable and valid experimental data under field conditions requires unusual attention to the problem of control. Scientific instrumentation and communications are prone to failure in the field. Environmental factors such as weather and illumination can change rapidly. The large number of people required, including player, support, and controller personnel, introduces a huge source of error. All these factors make it extremely difficult to achieve a properly standardized testing situation. These problems can be at least partially overcome by a number of techniques--for example, design of instrumentation for field use and experimental innovations, such as the Seeability Test in the present experiment--which make it possible to partial out the effects of some factors. Additionally, efforts should be made to demonstrate to all personnel the importance of their role and to increase their involvement in the experiment in order to motivate them to perform at a high level. Great attention must be paid to the training, cross-training, and retention of support and controller personnel. In spite of this attention, some failures will occur. Reduction in the number of failures and awareness of failure when it does occur are equally important and can be attained only by extremely detailed, redundant, and meticulously followed procedures which emphasize checks and cross-checks of all aspects of the experiment. Some of the major procedures used in the present experiment are described in this appendix. The procedures fall conveniently into four categories: 1) afternoon preparation, 2) evening preparation, 3) training, and 4) testing. Under each category the responsibilities of key personnel are described.

APPENDIX B

AFTERNOON PREPARATION

Test Director

The Test Director's responsibility is to collect all test material needed for the night's run and to insure that afternoon checkout is performed.

1. Obtain a weather report by calling the HLMR Weather Bureau at extension 5521.

2. Make vehicle and personnel assignments for the evening. The assignment task is conducted only when a key member is absent.

3. Dispatch the Electrical Engineer and Operations NCO to the test site to perform their afternoon checkout procedures.

4. Obtain a new magnetic tape from BESRL's storage lockers.

5. Make a phone call to the programmer for a status report on the data obtained from the previous evening. Note problems, if any, and contact the Electrical Engineer to determine possible resolutions.

6. Take a copy of the Scenario to the test site.

7. Replenish forms as needed:

   Practice forms
   Photometer log
   Nightly log
   Equipment log
   Player biography forms

8. Take the master test book to the test site each night.

9. Receive status reports from Electrical Engineer, Operations NCO, and Operations Officer.

Electrical Engineer

The Electrical Engineer's responsibility is to insure that all instrumentation is prepared for the night's run.

1. Generator check-out procedure.

   a. The generator control panel meters should read 208 volts 30 line to line and 60.0 cycles per second.

b. The generator power cables to the van should be connected line (L_1 L_2 or L_3) to neutral (L_0) to deliver 120 volts single phase.

2. Bringing up power in the van.

   a. Make sure main power switch inside the console is switched off.

   b. Turn on main light switch, circuit breakers, and safety switch.

3. Bringing up console power.

   a. Make sure Kennedy tape unit and Varian recorder are switched off.

   b. Make sure console main power cord is plugged in.

   c. Turn on main power switch inside the console.

   d. Check Sorensen power supplies for the following readings:

      QRE 7.5-10
      6.0 volts between 1 & 4 amps. (0 to 9 UDPs connected)
      QRE 7.5-50
      5.0 volts 20 amps

4. Console check-out procedure.

   a. Make sure Varian recorder has ample supply of toner, concentrate, and paper for duration of the experiment.

   b. Varian switches should be set as follows:

Chart speed	optional
Time	optional
Intensity	optional
Chart selector	A
Channel (1, 2, 3, 4)	off
Control	remote
Mode	synchronous
Scan	sequential

   c. With the Varian recorder and the selector in Console position, check-out dot coding for subject elevation and azimuth and for the digi-switch elevation and azimuth.

   d. Clean the Kennedy recording head and tape guides. Thread the tape; then switch the unit on. Be sure Kennedy selector switch is in the write position. Load the tape forward until ready. Now check for proper operation of the tape start and stop buttons.

e. Check for proper operation of delete, mark, and event buttons. Event buttons on the main panel are disabled when the remote event switch is connected.

f. Be sure all NIXIE tubes are lighted.

g. Check out "hot-line." (four headsets)

h. Check out Intercom.

i. Check out five channel intercom.

5. Encoder head check-out procedure.

   a. Be sure all scope mounting hardware is properly installed and is installed in the proper booth designated by the Test Director.

   b. Start the tape clock and turn on the training lamps toggle switch. Push the reset to clear lights.

   c. By using the NIXIE readout, check out each head:

      (1) Check ability to zero.

      (2) Check response buttons for proper operation of player response lamp, training lamps, and annunciator. Check operation of panel reset button.

      (3) Check for proper sign in NIXIE readout for up-down and left-right head movement. (Down and left are negative.)

      (4) Be sure tripods are level and the pan-heads are tight. The pan-heads should be adjusted as close to being level as possible. All set screws should be tightened.

      (5) If time permits, each head should be zeroed and then a check performed on a known reference point. This step must be performed again immediately before the training session.

6. The Varian recorder should be recording before the tape is made ready to accept data. The Varian should not be switched to standby or off during the course of the experiment, except in an emergency.

7. Give the Test Director an instrumentation status report.

Operations NCO

The Operations NCO insures that the experimental site is prepared for the night's run.

1. Make general inspection of site.

2. Check all radios. If radio will not function, replace batteries and/or perform suitable first echelon maintenance. If radio still does not function, replace with backup radio. Turn non-functioning radio in for repair and secure another radio as backup.

3. Check all land-line telephones. Have lines and/or telephones repaired or replaced as necessary.

4. Give Test Director a status report on condition of site and communications.

Operations Officer

The Operations Officer is responsible for coordinating all military aspects--administrative, personnel, and logistic--in support of the research. Further, he serves as liaison to his own command on all stages of the research.

1. Determine that all logistic support will be available and on schedule.

2. Give Test Director a status report on logistic support.

APPENDIX B

EVENING PREPARATION

Test Director

The Test Director arrives at the site about fifteen minutes before the arrival of cadre with all forms, schedules, and scenarios that will be needed for the night's run.

1. Check with the Electrical Engineer for any change in the status of the instrumentation.

2. Post the nightly schedule.

3. Insure that the checklists are at each position in the Experimental Control Center.

    Van, Console operator (Assistant Electrical Engineer).
    Van, Varian operator
    Test Director
    Scenario Director
    Assistant Scenario Director (target controller)

4. Distribute training forms to the Assistant Electrical Engineer and the Scenario Director.

5. Receive status reports from the following personnel:

    a. Test Scientist - Booth, devices, intercom and player status

    b. Scenario Director - Support vehicle, commo, test equipment, roadguard, ambulance, and general site security status

    c. Assistant Scenario Director - Target personnel and target vehicle status

    d. Electrical Engineer

        Tape mounted
        Devices mounted and secure
        Tripod and encoder security
        Ready for practice

    e. Training NCO

        Device log completed
        Instructors briefed and standing by

6. Briefings.

   a. Give civilian briefing following military briefing.

   b. Supervise instrumentation briefing and target commo check-in.

   c. Give device instructions in briefing building.

7. Receive final preparation reports.

   a. Test Scientist: Weather and moon position

   b. Training NCO: Players in appropriate booths

   c. Assistant Scenario Director: Targets in position with all commo operational

<u>Scenario Director</u>

The Scenario Director arrives with the cadre. His primary responsibilities are to 1) control the targets so they are in position and respond in exact accordance with the prepared scenarios and 2) read instructions to the players for all phases. His responsibilities for the preliminary phase are to assist the Test Director.

1. Tell the Assistant Scenario Director when to dispatch targets.

2. Tell the Assistant Scenario Director when to dispatch roadguard vehicles.

3. Inform the Test Director on the following:

   a. Operational status of commo.

   b. Condition of site.

   c. Arrival of cadre and any special problems.

   d. Arrival of subjects and any special problems.

   e. Any target problems (personnel and vehicular).

   f. Ambulance.

   g. Disposition of roadguard vehicles.

   h. When targets are in place.

4. Distribute stopwatches to Test Director, Test Scientist, Scenario Director, and Assistant Scenario Director.

Assistant Scenario Director

The Assistant Scenario Director is the target controller. He arrives with the cadre and is the NCO in charge of the target array personnel.

1. Check the schedule.

2. Check the scenario.

3. Distribute telephones to the targets.

4. Brief the target array on the schedule and scenario for the evening.

5. Insure that all targets understand their assignments, movements and jobs.

6. Check the vehicle status to insure that all vehicles operate.

7. Install PRC-10 radio on 5-ton truck.

8. Perform commo checks with all vehicles.

9. Perform commo check with roadguards.

10. Give a status report to the Test Director concerning:

    a. Target array muster; any new personnel, problems, etc.

    b. Targets briefed.

    c. Vehicles running and all radios operational.

    d. Targets standing by to go down field.

11. Send targets down field upon command from the Scenario Director.

12. Perform target check-in, commo check on the land line telephones.

13. Complete target position checklists.

14. Report to Scenario Director that targets are in place and ready.

Target Personnel

The target personnel arrive at the test site with the cadre. It is essential that the target know his locations and that he can maneuver to these positions rapidly with use of flashlight only. During training and testing his positions and mode will be in accordance with a prepared schedule and he will move and appear upon order of the Assistant Scenario

Director. It is also essential that the target move to and from defilade positions rapidly. When in defilade he must be perfectly concealed from the players. The target should wear unstarched fatigues. He should have the necessary personal equipment with him when he arrives at the test site--canteen, sleeping blanket, etc. Upon arrival at the test site, the target personnel will:

1. Receive a briefing from the Assistant Scenario Director on the purpose of the night's run and the schedule.

2. Obtain land-line telephones and flashlights from the Assistant Scenario Director.

3. Check the telephone boxes for general security and fresh batteries.

4. Stand by for moving down field to appropriate target locations.

5. Vehicle commanders will perform routine inspections of their vehicles and make a radio check with the Assistant Scenario Director as soon as practical after arriving at the site.

6. Move to their assigned field positions according to the schedule and general movement plan.

7. Upon arrival at each target location, connect telephones, assume the defilade position, and call the Assistant Scenario Director for a commo check.

8. Stand by in defilade for the beginning of training.

Test Scientist

The Test Scientist arrives at the site approximately 15 minutes before the cadre is scheduled to arrive. He assists the Test Director in the distribution and handling of forms, checklists, and scenarios.

1. Insure that all the pre-test materials are on hand and ready to go.

2. Insure that the Training NCO has all of the necessary materials in his possession.

3. Observe the handling of players to make sure it is in accordance with the procedure.

4. Inform the Test Director of any departure from plans or procedures.

5. After the devices have been mounted by the instructors, and after the devices and mountings have been checked by the Electrical Engineer, perform final inspection of each booth with the Training NCO. In each booth, check the following items and make sure information is entered into the Device Log by the Training NCO:

   a. Device number, UDP number.

   b. Device operational check.

      (1) Device turn-on.

      (2) Reticle in view.

      (3) Battery date.

   c. General security of the installation.

      (1) Tightness of mounting.

      (2) Security of pin installation.

   d. Lenses clean.

   e. Commo system operational.

6. Give status report to the Test Director:

   a. Booth, devices and intercom status.

   b. Player status.

   c. Players ready for briefing or estimated time that they will be ready.

7. Give the civilian briefing if the Test Director cannot.

8. Give the instrumentation briefing at the conclusion of the civilian briefing.

9. Check the ambient light and give "ready or not" report to the Test Director.

10. Return to the line to observe performance on the line and answer any questions that may occur.

Electrical Engineer

The Electrical Engineer has been on site since the beginning of the checkout activity. He continues his equipment checkout and repair activities. Starting with the arrival of the Test Director. he will perform the following tasks:

1. Receive a new data tape from the Test Director.

2. Mount the new tape.

3. After the cadre arrives and the instructors mount the devices, take position on the line, with the Assistant Electrical Engineer at the control console.

   a. Check each device installation, the tripods, and the response buttons.

   b. Check the hot-line communication system.

   c. Check the security of the attachment of the devices to the panheads.

4. Give the Test Director a status report on the device installation and security.

5. Perform zeroing operation immediately prior to the civilian and military briefing.

   a. Tripod height must have been set to the player's height by the instructor.

   b. Each instrumentation head must be calibrated by the following procedure:

      (1) Place the crosshair on the lighted zero reference panel (the left limit sign).

      (2) Inform the Assistant Electrical Engineer via the hot-line that the device is positioned for zeroing.

      (3) Have the Assistant Scenario Director press the reset button for the booth.

      (4) Repeat the operation until all nine booths have been zeroed.

6. Continue surveillance of the instrumentation system and stand by until the beginning of practice.

Assistant Electrical Engineer

The Assistant Electrical Engineer arrives at the test site with the cadre. It is his responsibility to assist the Electrical Engineer.

1. Report to Electrical Engineer.

2. Prepare the photometer for operation and perform weekly calibrations and/or operational check on the instrument (see photometer procedure).

3. After the devices have been mounted by the instructors, assist the Electrical Engineer in the checkout of the devices and mounts by taking position at the control console while the Electrical Engineer is in the booths. With the Electrical Engineer, check the following:

   a. The device swing on the tripods.

   b. The response buttons.

   c. Readings for the limit of search area.

4. Assist the Electrical Engineer with any required set-up maintenance.

5. When the devices are mounted and the booths are properly set up, complete the console checklist (the practice target catalogs, practice forms, and a stopwatch).

6. Assist the Electrical Engineer with the zeroing procedure.

Training NCO

The Training NCO arrives at the site at least fifteen minutes prior to the scheduled arrival of the cadre. He must insure that all materials and forms are ready to be distributed to the instructors when they arrive.

1. Obtain the schedule of the evening from the Test Director.

2. Make sure that a sufficient supply of device oscillators, batteries, lens cleaning tissue, flashlights and batteries, clipboards, and instructions are on hand.

3. Report any envisioned shortages to the NCOIC and the Test Director.

4. Perform a communication check of the intercom in each booth.

5. Insure that lens tissue is available for each instructor.

6. Supervise the unloading and setup of each device, making sure that the devices are mounted in the proper booths.

7. Personally check the operation and status of each device.

8. Check each instructor's clipboard for the proper script.

9. Check all of the instructor's flashlights and batteries for proper operation.

10. Report instructor status to the Test Director (any changes in personnel, procedural problems, device problems, etc.).

11. Assist the Test Scientist in the final check of each booth and device, by completing the equipment log.

12. Brief the instructors on the night's schedule.

13. Escort players when and where appropriate.

14. Supervise the movement and discipline of the instructors and players to the line for the beginning of practice or warm-up.

15. Insure that instructors and players are in the correct booths.

16. Insure that all booth doors remain open, and that the distracting movement and noise are kept to a minimum on the line.

Instructors

The instructors arrive at the site with the cadre. It is their responsibility to prepare their booths for the night's run.

1. Unload, assemble, and mount the devices in your booth. Whenever possible, mount the same device (by serial number) in the same booth each night.

2. Clean the lenses.

3. Check the operation of the device.

   Focus (movement stop to stop).

   Diopter (movement/freedom of movement).

   Oscillator (humming).

   Reticle (make sure that there is one visible).

   Change batteries (obtain new ones from the Training NCO) on the first test night of each week.

4. Get flashlights and clipboards of instructions from the Training NCO.

5. Check to be certain that the instructions on the clipboard are for the device in your booth.

6. Report any problems with the device or security of the mounting to the Training NCO immediately.

7. Receive a briefing on the purpose of the night's run from the Training NCO.

8. Bring player into booth for height adjustment. During player briefings, assist the Electrical Engineer in zeroing devices if necessary.

9. Stand by to escort players.

10. Assemble and pick up players upon direction from the Training NCO.

11. Move player to the booth.

12. Booth doors are to remain open at all times.

13. Stand by for instructions to begin practice.

14. Do not discuss the experiment with the players.

APPENDIX B

TRAINING

Test Director

It is the responsibility of the Test Director to insure that training procedures are properly carried out. In order to accomplish this, he will:

1. Initiate training according to the schedule.

2. Give initial instruction on devices or delegate this task.

3. Closely monitor all phases of training.

4. Determine which players, if any, need additional training and insure that such training is accomplished.

Scenario Director

It is the responsibility of the Scenario Director to: 1) read portions of the training instructions to the players; 2) present targets in accordance with the scenario; and 3) receive reports on player behavior to insure that individual training is proceeding in a satisfactory manner. Training is divided into three parts.

PART I

1. Read appropriate instructions.

2. Order practice target into position with light on.

3. Receive confirmation on target from Assistant Scenario Director and Target Monitor.

4. Instruct players to start.

5. Receive report from Assistant Electrical Engineer that all players have found target.

6. Order target to extinguish light.

7. Receive confirmation of "light off" from Assistant Scenario Director and Target Monitor.

8. Time target exposure with light off (60 seconds).

9. Instruct players to stop.

10. Order target down.

11. Inform appropriate instructor when player is having difficulty.

12. Repeat steps 1 - 11 until completion of PART I.

PART II

1. Read appropriate instructions.

2. Order target into position with light on.

3. Receive confirmation from Assistant Scenario Director and Target Monitor.

4. Time target exposure.

5. After 30 seconds, tell instructors to assist players who have not found light.

6. After 60 seconds, order light off.

7. Receive confirmation from Assistant Scenario Director and Target Monitor.

8. Order alerting of next target by Assistant Scenario Director.

9. After 120 seconds, order target down.

10. Receive confirmation from Assistant Scenario Director and Target Monitor.

11. Receive report on players having difficulty from Assistant Electrical Engineer.

12. Inform appropriate instructor when player is having difficulty.

13. Repeat steps 2 - 12 until completion of PART II.

14. Instruct players to stop.

PART III

1. Procedures same as in PART II except that targets never have light on and instructors do not assist players.

2. Tell instructors to take players to rest tent.

3. Inform Test Director that training is completed.

Assistant Scenario Director

It is the responsibility of the Assistant Scenario Director to: 1) direct target presentation in accordance with the orders given by the Scenario Director and 2) assist the Scenario Director in the execution of his duties.

PARTS I AND II

1. In accordance with the scenario and upon command from the Scenario Director, alert the next target one minute prior to its exposure and receive confirmation.

2. Upon command from the Scenario Director, order the target up with light on and receive confirmation.

3. Signal the Scenario Director when target reports that it is up, in the correct position, and in correct movement mode.

4. Check the Scenario Director to insure that he has started timing target exposure.

5. Record the target identification by checking the scenario list.

6. Upon command from the Scenario Director, order the target to extinguish his light and receive confirmation.

7. Upon command, order target down and receive confirmation.

8. At all times, monitor Scenario Director to insure that he is following correct procedures.

9. Repeat steps 1 - 8 until scenario is complete.

PART III

Procedures same as PARTS I and II except that all targets are presented without lights, with corresponding changes in procedures.

Target Personnel

It is the responsibility of a target to follow the instructions of the Assistant Scenario Director at all times. The target is cautioned against the following during training and testing.

Do not smoke, except when told that smoking is permitted.

Do not have lights on unless instructed to.

Do not have shiny objects, either in hand or worn.

Do not move into view without instruction.

Do not have the instrument panel of a vehicle on.

Do not have brake lights operational.

Do not use head or tail lights.

Do not have the instrument panel facing the players (cover panel).

Do not make loud noises.

Do not throw trash on the range.

PARTS I AND II

A target will be required to follow several instructions during PART I and PART II of the training session. These are:

1. Assistant Scenario Director to Target: "Target X, you are next static (or dynamic), with light." This instruction will be given one minute before the target is due.

2. Target reply with "Roger."

3. Assistant Scenario Director to Target: "Target X up, dynamic (or static) with light on."

4. Target reply with "Away" when moving toward assigned position. Move rapidly and hold light toward the ground.

5. When in position (either static or dynamic), respond with "Up." The light should be held so that it shines on the target or his vehicle.

   a. If in the static mode, stand perfectly still.

   b. If in the dynamic mode, move along assigned path at proper speed. Remember the position of the light--never shine the light toward the players.

6. Assistant Scenario Director to Target: "Target X, light off."

7. The target will turn the light off and respond with "light off."

8. Assistant Scenario Director to Target: "Target X, go down."

9. Target will reply "Away" as he begins to move rapidly toward his concealed position.

10. When in the concealed position, the target will respond "Down."

PART III

Reporting procedures will be the same as in PARTS I and II, but no lights will be used.

Electrical Engineer

The Electrical Engineer is responsible for: 1) the correct functioning of the instrumentation at all times; 2) supervision of the Assistant Electrical Engineer. If an instrumentation malfunction occurs, the Electrical Engineer will immediately inform the Test Director of the nature of the malfunction, its seriousness, and estimated time to repair. Upon instruction from the Test Director, he will undertake correction of the malfunction.

Assistant Electrical Engineer

It is the responsibility of the Assistant Electrical Engineer to: 1) assist the Electrical Engineer in the accomplishment of his duties; 2) monitor player responses via the monitoring console; 3) inform the Test Director when players are not following correct procedures and/or are having difficulty in finding targets.

PARTS I AND II

A sequential listing of procedures for the first practice target is given below. The same procedure is repeated for each succeeding practice target.

1. The target appears with a light on itself.

2. When a player finds the target and aligns his crosshair on it, he presses his response button. This action lights the player's training lamp on the master control panel.

3. The Assistant Electrical Engineer scans each player's elevation and azimuth readings via the NIXIE tubes and compares the readings to previously surveyed true values. By this procedure, he can determine which players have truly found the target. The Test Director is informed of which players are having difficulty.

4. When all the training lamps are lighted and all players have correct azimuth and elevation values, the Assistant Electrical Engineer informs the Scenario Director that all players have found the target.

5. The Scenario Director will respond with the command, "Light out." At this time, the target turns off his light and the van resets the training lamps.

6. The players have one minute after "Light out" to re-find the target and push their response buttons. At the end of the one-minute period, the Assistant Electrical Engineer informs the Scenario Director of any players who have failed to push their response buttons.

7. The Scenario Director will respond with the command, "Target down." At this time, the Assistant Electrical Engineer resets the training lamps and is ready for the next target.

PART III

1. Targets are presented without lights and procedures are modified accordingly.

2. Player responses are monitored via training lamps and NIXIE tubes, and successful target acquisition is recorded.

3. At the conclusion of PART III, the Test Director is given the performance scores of each player.

4. After the last practice target, the experimental tape is mounted. The selector switch of the Varian recorder should be in the record position. The Varian must not be turned to off or standby while the tape unit is running.

5. The instrumentation is now ready for an experimental run.

Test Scientist

It is the responsibility of the Test Scientist to: 1) give portions of the training instructions, as directed by the Test Director, 2) monitor the activity of the instructors and players during the training session, 3) assist the Training NCO in answering questions from the instructors and players, and 4) report to the Test Director any factors which could delay or degrade the effectiveness of training.

Training NCO

It is the responsibility of the Training NCO to: 1) maintain control over the instructors and players, 2) insure that instructors and players are following proper procedures, and 3) answer any questions from instructors and players, with the assistance of the Test Scientist, if necessary.

Instructors

It is the responsibility of the instructor to: 1) read portions of the instructions to the player and assist him in making diopter adjustment, 2) answer any questions by the player, 3) assist player in finding practice targets, and 4) monitor the behavior of the player at all times.

PART I

1. Instructor and player will go to their assigned booth.

2. The instructor and player will listen to the instructions read by the Scenario Director over the booth intercom.

3. Upon command from the Scenario Director, the instructor will read his portion of the instructions and assist the player in making the diopter adjustment.

4. The instructor will inform the Scenario Director when instructions are completed and assume position in front of his assigned booth but out of line of sight of the players.

5. Instructor will assist player in finding practice targets.

6. Instructor will answer any questions of the player, with the help of the Training NCO.

PART II

1. The instructor will remain in front and to the side of assigned booth.

2. Upon command from the Scenario Director, he will assist the player to find targets.

PART III

1. The instructor will assume his position to rear of the assigned booth.

2. He will monitor the behavior of the player and, if necessary, will instruct the player to continue to search.

3. He will respond to all communications over the intercom system.

4. When training is completed, he will stand by with his player until told to escort the player to the rest tent.

General

1. The instructor will be responsible for the booth and its contents.

2. He will not permit horseplay, drinking of liquor, smoking, or loud talking around his booth.

3. The door to the booth will remain open.

Target Monitor

It is the responsibility of the Target Monitor to: 1) continuously monitor target activities, 2) provide the Scenario Director with verification of all target reports, and 3) report to the Scenario Director light security violations, improper concealment of targets, and changes in light and weather conditions.

1. The Target Monitor will be in a booth equipped with a NOD on the test line.

2. He will be familiar with all target locations and will be given the order of presentation prior to each night's run.

3. He will monitor all commands to the targets via the hot line.

4. He will verify all target reports and notify the Scenario Director.

APPENDIX B

TESTING

Test Director

It is the responsibility of the Test Director to insure that valid data are collected during the testing phase of the experiment. All major actions are initiated by the Test Director and all violations of procedures are reported to him. He maintains a constant check of instrumentation status, player performance, target status, and ambient light and weather conditions. He is sensitive to time (schedule) constraints as they are affected by delays in testing and environmental-illumination conditions. On the basis of all this information, he makes decisions to delay, delete targets, delete players, abort run, etc., fully weighting the implications of each action in the field for data reduction and analysis. He maintains a detailed nightly log of all factors that could affect the validity of the data collected and/or data reduction and analysis.

Scenario Director

The Scenario Director is responsible for: 1) assisting the Test Director in the execution of his duties, 2) reading the appropriate instructions to the players, 3) controlling target exposure in accordance with the scenario, and 4) marking magnetic tape via his desk console to indicate target presentation.

1. Order dispatch of targets and photometer operator.

2. Order final pre-test instrumentation check.

3. Receive confirmation of target and instrumentation status.

4. Order players to booths.

5. Order light security.

6. Receive confirmation of player status and light security.

7. Read appropriate instructions.

8. Order presentation of first target.

9. Receive confirmation that first target is up.

10. Instruct players to begin searching.

11. Start timing target exposure and put event mark switch on.

12. Order next target alerted one minute prior to exposure time. Receive confirmation of "Roger."

13. Order next target alerted 10 seconds prior to exposure time. Receive confirmation of "Roger."

14. Order first target down (2 minutes after exposure).

15. Receive confirmation of target down and turn event marking switch off.

16. Order next target up.

17. Receive confirmation that target is up, start timing target exposure and put event marking switch on.

18. Repeat steps 12 - 17 until scenario is completed.

19. Instruct players to stop searching and turn away from field.

20. Give 5-minute break in place after every 12 targets.

21. Send players to rest tent after 24 targets (trials).

22. Order targets to move to new positions after 24 trials.

23. Order instrumentation check after 24 trials.

24. Repeat steps 3 - 23 until 72 targets have been presented.

25. Read instructions for Seeability Test.

26. Order presentation of first target and receive confirmation.

27. Inform players of the location of target.

28. Receive confirmation that all players have found and shot target.

29. Order light extinguished on first target and receive confirmation.

30. Turn event marking switch on and start timing target exposure.

31. Order target down after appropriate time.

32. Receive confirmation of target down and turn event marking switch off.

33. Order presentation of next target and receive confirmation.

34. Repeat steps 27 - 33 until all targets have been presented.

35. Order players to rest tent.

36. Order targets to come in.

37. Debrief players.

Assistant Scenario Director

It is the responsibility of the Assistant Scenario Director to: 1) communicate with the targets upon command by the Scenario Director and 2) continuously monitor the Scenario Director to insure that he is following correct procedures.

1. When instructed by the Scenario Director, alert the next target: "Target number ___. You are next and ___ (dynamic or static). One minute to go."

2. Receive target reply.

3. When instructed, alert the next target: "Target number ___. Ten seconds."

4. Receive target reply.

5. When instructed, instruct the target to go down: "Target number ___. Go down."

6. Receive target reply and signal Scenario Director that target is down.

7. When instructed, bring the next target up: "Target number ___. You are up and ____ (dynamic or static)."

8. Receive target reply and signal the Scenario Director that target is up.

9. Repeat steps 1 - 8 until scenario is completed.

10. If target fails to reply, immediately inform the Scenario Director.

11. When instructed, inform the target array about movement to new locations.

12. During the Seeability Test, these procedures are modified. When instructed by the Scenario Director, say, "Target number ___. You are up with light on" and receive reply. When instructed, say, "Light off" and receive reply. Other procedures remain the same.

Target Personnel

It is the responsibility of the targets to: 1) respond rapidly to all communications from the Assistant Scenario Director, 2) upon command, to move rapidly between defilade and the correct target location, and 3) when in the dynamic mode, to move along the assigned path at the correct speed.

1. When alerted by the Assistant Scenario Director, the Target should respond with a "Roger."

2. When told by the Assistant Scenario Director that he is up, the target should respond, "Away," as he begins to move rapidly from his concealed position. When he is in position, he should respond with "Up."

3. When told by the Assistant Scenario Director that he is down, the target should respond with "Away," as he begins to move toward his concealed position. When he is fully concealed, he should respond with "Down."

4. In the Seeability Test, this procedure is modified. When the target is in position with his light on, he should respond, "Up, light on." When instructed by the Assistant Scenario Director to extinguish his light, the target should turn his light off and reply, "Light off," but remain in position. Other procedures remain the same.

Electrical Engineer

The electrical Engineer is responsible for: 1) the correct functioning of the instrumentation at all times and 2) supervision of the Assistant Electrical Engineer. If an instrumentation malfunction occurs, the Electrical Engineer will immediately inform the Test Director of the nature of the malfunction, its seriousness, and estimated time to repair. Upon instruction from the Test Director, he will undertake correction of the malfunction.

Assistant Electrical Engineer

It is the responsibility of the Assistant Electrical Engineer to: 1) assist the Electrical Engineer in the accomplishment of his duties, and 2) continuously monitor the player responses and instrumentation status and inform the Test Director of any problems.

1. When the player presses his response button, the response lamp will light. The Assistant Electrical Engineer will monitor these lamps to determine whether the players are firing and the rate of firing. A very high rate of firing, for example, would indicate that the player was pressing his response button indiscriminately, i.e., was not following correct procedures. If a response lamp remains on, it would indicate that the player was holding the button down or that the button was stuck.

2. Changes in elevation and azimuth are presented in real time on the elevation and azimuth displays (NIXIE tubes). The Assistant Electrical Enginner will monitor these displays. If the elevation and azimuth do not change, it indicates either equipment malfunction or or that the player has stopped searching. If the elevation and azimuth displayed are beyond the prescribed limits, it indicates either that the instruments should be re-zeroed or that the player is not following correct procedures.

3. Any observations related to instrumentation or player failure should be immediately communicated to the Test Director.

4. After each block of 24 trials, the Assistant Electrical Engineer will assist the Electrical Engineer in the re-zeroing of the instruments, and deviations will be noted.

5. During the Seeability Test, the Assistant Electrical Engineer will monitor response lamps and displays and inform the Scenario Director when all players have found the lighted target.

Test Scientist

It is the responsibility of the Test Scientist to: 1) exercise general supervision of activities outside of the Experimental Control Center and 2) inform the Test Director of any factors that could delay testing and/or affect the validity of the data being collected.

Training NCO

It is the responsibility of the Training NCO to: 1) maintain control over the instructors, players, and target monitors, 2) insure that instructors, players, and target monitor are following the proper procedures, and 3) answer any questions from instructors or players, with the assistance of the Test Scientist.

1. The Training NCO will inspect each device and its mounting prior to the beginning of testing and at all breaks during testing.

2. The Training NCO will have available on the booth line:

   a. Two (2) BA 1100s

   b. One (1) box of lens tissue

   c. One (1) oscillator

3. If a problem arises, the Training NCO will furnish the Test Director with the following information:

   a. Nature of problem

   b. Location

   c. Possible solution

   d. Estimated time to correct

4. Upon completion of testing, the Training NCO will insure that all tripods, UDPs, and devices are properly secured.

<u>Instructors</u>

It is the responsibility of the instructors to: 1) monitor the behavior of the player at all times, 2) answer relevant questions by the player, and 3) immediately inform the Scenario Director and Training NCO of any device or player problems. General responsibilities are the same as during training.

<u>Target Monitor</u>

It is the responsibility of the Target Monitor to: 1) continuously monitor target activities, 2) provide the Scenario Director with verification or target reports, and 3) report to the Scenario Director any light security violations, improper concealment of targets, and changes in light and weather conditions. General procedures remain the same as during training.

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13. ABSTRACT The NIGHT OPERATIONS program within the Behavior and Systems Research Laboratory is concerned with problems in optimizing human performance in relation to night vision devices and related sensors. In the furtherance of this research, BESRL established a field unit at Fort Ord, California where, in conjunction with the Combat Develments Command Experimentation Command (CDCEC), human performance experimentation has been conducted directed toward enhancement of the performance of the combat soldier in night operations. Specifically, in the first of a series of research phases, operational objectives were two-fold: 1) to determine which factors affect performance with passive night vision devices, and to what extent, and 2) to identify and develop means of improving performance effectiveness.

Performance with four devices was evaluated in the experimental procedure: the Miniscope (MINI), Starlight Scope (SS), Crew-Served Weapon Night Vision Sight (CSWS), and the Night Observation Device, Medium Range (NOD). At a rate of nine per night, 123 operators were tested under three varied ambient illumination levels in the search and detection of 72 targets which differed in type, contrast, and mode and which were stationed at a distance of 100 to 1200 meters. Detection responses and search behavior were recorded on magnetic tape for data analysis. Major findings indicated: 1) Operators differed greatly in target detection ability during search (with low reliability in detection of specific targets); 2) Relatively long periods (at least 6 hours) of almost continuous use of the devices were maintained without performance degradation; 3) Performance with the NOD was superior to that with other devices; 4) Pairs of operators using the same type devices detected about 50% more targets than did single operators (any mix which included the NOD improved performance); 5) Performance was

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14. KEY WORDS	LINK A ROLE	LINK A WT	LINK B ROLE	LINK B WT	LINK C ROLE	LINK C WT
*Night observation						
Surveillance systems						
*Night vision devices						
*Sensors						
*Sensor systems						
MINI						
SS						
CSWS						
NOD						
*Ambient light levels						
Illumination conditions						
Target modes						
*Search behavior						
*Detection response						
Target - terrain factors						
*Field experimentation						
Operator performance measurement						
Mix						
Training						
Research methodology						
Military psychology						
*Search techniques						
Target - background contrast						
Target types						
Instrumentation						

Unclassified

Security Classification

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13. Abstract - continued

significantly affected by a number of environmental-target-terrain factors including ambient light, distance, target type, and target-background contrast. Faulty search techniques was determined the primary cause of inefficient performance. The present publication is an initial report and because of the continuing availability of performance information, does not represent a complete analysis of results. A report containing more detailed analysis is in preparation, as are reports of additional experimentation.

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